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MATHEMATICS.—*On the balance between deformation and rotation in the motion of a continuous medium.*[1] C. TRUESDELL, Naval Research Laboratory.

A fundamental theorem[2] of Cauchy and Stokes states that the most general continuous motion of a medium may be resolved locally and instantaneously into a translation, an extension along three mutually orthogonal axes, and a rigid rotation of these axes. If $\mathbf{v}$ denote the velocity vector, then a proper measure of the rate of rotation is afforded by the vorticity vector $\mathbf{w}$:

$$w_i \equiv -e_{ijk}v_{j,k}\,, \tag{1}$$

while a proper measure of the extension is afforded by the rate of deformation tensor $\mathbf{d}$:

$$d_{ij} \equiv \tfrac{1}{2}(v_{i,j} + v_{j,i}). \tag{2}$$

The first purpose of the present paper is to show that in a large class of motions these two quantities are not altogether independent but must submit their relative contributions to the control of a relation connecting the space averages of certain associated scalar magnitudes. These scalars are the vorticity magnitude:

$$w \equiv \sqrt{w_i w_i}\,, \tag{3}$$

and the second invariant of $\mathbf{d}$:

$$II_d \equiv \tfrac{1}{2}e_{ijk}e_{ilm}d_{jl}d_{km}\,. \tag{4}$$

Our analysis is purely kinematical, and thus is valid for continuous motions of all types of media.

Writing $\theta \equiv \operatorname{div}\mathbf{v} = v_{i,i}$, we have

$$\begin{aligned}(v_i v_{j,i} - \theta v_j)_{,j} &= -\theta^2 + v_{i,j}v_{j,i}\,,\\ &= -\theta^2 + (d_{ij} + \tfrac{1}{2}[v_{i,j} - v_{j,i}])\\ &\qquad (d_{ji} + \tfrac{1}{2}[v_{j,i} - v_{i,j}]),\\ &= -\theta^2 + d_{ij}d_{ij} - \tfrac{1}{2}w^2.\end{aligned} \tag{5}$$

Now in terms of the principal rates of extension d_i we have

$$\begin{aligned}&-\theta^2 + d_{ij}d_{ij}\\ &\quad = -(d_1 + d_2 + d_3)^2 + d_1^2 + d_2^2 + d_3^2,\\ &\quad = -2(d_1d_2 + d_2d_3 + d_3d_1),\\ &\quad = -2II_d,\end{aligned} \tag{6}$$

and hence (5) becomes

$$(v_i v_{j,i} - \theta v_j)_{,j} = -2II_d - \tfrac{1}{2}w^2. \tag{7}$$

If we integrate this identity over a volume and then apply the divergence theorem to the result, we obtain

$$\int_V (4II_d + w^2)\,dV = 2\oint_S dS_j[v_j\theta - v_i v_{j,i}]. \tag{8}$$

Since the acceleration $\mathbf{a}$ is given by

$$a_j = \frac{\partial v_j}{\partial t} + v_i v_{j,i}, \tag{9}$$

we may put (8) into the alternative form

$$\int_V (4II_d + w^2)\,dV = 2\oint_S dS_j\left[v_j\theta - a_j + \frac{\partial v_j}{\partial t}\right]. \tag{10}$$

By formulating conditions under which the surface integral on the right vanishes, we obtain the following THEOREM OF AVERAGE BALANCE BETWEEN VORTICITY AND DEFORMATION: *If all finite boundaries of a continuously differentiable motion be stationary, and if upon them the material adhere without*

[1] Received August 22, 1950.
[2] E.g., §30 of LAMB, *Hydrodynamics*, ed. 6. Cambridge, 1932.

slipping ($\mathbf{v} = 0$), *while in any portion of the material extending to* ∞ *the condition*

$$r^2\left(a_r - \frac{\partial v_r}{\partial t} - \theta v_r\right) \to 0 \qquad (11)$$

be satisfied, then the average value of $4II_d + w^2$ *throughout the motion is zero:*

$$\int_V (4II_d + w^2)\, dV = 0. \qquad (12)$$

COROLLARY 1. *For a motion of the type described in the theorem to be rotational* ($\mathbf{w} \neq 0$) *it is necessary that there exist within it a region where*

$$II_d < 0. \qquad (13)$$

COROLLARY 2. *In an irrotational motion* ($\mathbf{w} = 0$) *satisfying the hypotheses of the theorem the average value of* II_d *is zero:*

$$\int_V II_d\, dV = 0. \qquad (14)$$

COROLLARY 3. *In an isochoric*[3] *motion of the type described in the theorem the average value of the squared vorticity must equal twice the average value of the squared intensity of deformation:*

$$\int_V w^2\, dV = 2\int_V d_{ij}d_{ij}\, dV. \qquad (15)$$

The proofs of corollaries 1 and 2 are immediate, and corollary 3 follows from (6). We notice in passing that from corollary 3 and the fact that $d_{ij}d_{ij} > 0$ if $\mathbf{d} \neq 0$ we may obtain a proof of the well-known theorem on the impossibility of irrotational motions in a finite domain to whose boundaries the material adheres.

The theorem of average balance states that in a broad class of motions the average value of the invariant $4II_d + w^2$ is zero. We may now seek to characterize those motions in which this average balance between deformation and vorticity is satisfied by the exact balance $4II_d + w^2 = 0$ at every point. The condition $4II_d + w^2 = 0$ occurs in a recent work of Bilimovitch,[4] who investigated the possible generalization of an earlier and apparently unrelated theorem of Pompeiu.[5] Guided by the outcome of this study, we shall present a somewhat more general analysis, which will yield the theorem of Bilimovitch as a special case.

Let a closed surface S be given by the parametric vectorial equation $\mathbf{r} = \mathbf{r}(l, m)$. Then from the divergence theorem it follows that the volume V_S enclosed by S is given by

$$3V_S = \oint_S d\mathbf{S}\cdot\mathbf{r} = \oint_S \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m}\cdot\mathbf{r}\, dl\, dm, \qquad (16)$$

where a plus or minus sign is attached quite arbitrarily to V_S as a consequence of the manner of parametrization. Now consider the velocity vector $\mathbf{v}(\mathbf{r}, t) = \mathbf{v}(\mathbf{r}(l, m), t) = \mathbf{v}(l, m, t)$ at the points $\mathbf{r}$ upon S. The termini of these vectors sweep out a surface, whose enclosed volume V_V is obtained by replacing $\mathbf{r}$ by $\mathbf{r} + \mathbf{v}$ in (16), viz.

$$3V_V = \oint_S \frac{\partial(\mathbf{r} + \mathbf{v})}{\partial l} \times \frac{\partial(\mathbf{r} + \mathbf{v})}{\partial m} \cdot(\mathbf{r} + \mathbf{v})\, dl\, dm. \qquad (17)$$

We shall call V_V the *velocital volume* of the surface. If the origins of these same velocity vectors be put at the origin of co-ordinates, their termini sweep out a third surface, whose enclosed volume V_H is given by

$$3V_H = \oint_S \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m}\cdot\mathbf{v}\, dl\, dm. \qquad (18)$$

We shall call V_H the *hydrographic volume* of the surface. The parameters l and m are selected once for all in the parametrization of S, so that the parametrization in (17) and (18) is induced by this initial choice;

[3] An isochoric motion is one in which the volume of the portion of space occupied by each material volume is constant in time: $\theta = 0$.

[4] BILIMOVITCH, A., *Aires et volumes vélocidiques et hodographiques dans un mouvement du fluide*, Acad. Serbe Sci. Publ. Inst. Math. **2:** 37–52. 1948. In my review (Math. Rev. **10:** 517. 1949) of this paper the factor 4 is erroneously omitted from the condition.

[5] POMPEIU, D. *Sur la condition des vitesses dans un fluide incompressible*, Bull. Math. Phys. École Poly. Bucarest **1:** 42–43. 1929. Other generalizations of Pompeiu's result are obtained by C. Jacob, *Sur une interprétation de l'équation de continuité hydrodynamique*, Bull. Math. Soc. Roumaine Sci. **46:** 81–90. 1944.

in particular, while the sign of V_S is arbitrary, the signs of V_V and of V_H are induced by it. By multiplying out in (17) we obtain

$$\begin{aligned} 3V_V = \oint_s \Big\{ &\frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} \cdot \mathbf{r} + \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \cdot \mathbf{v} \\ &+ \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} \cdot \mathbf{v} + \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \cdot \mathbf{r} \\ &+ \left[\frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} + \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \right] \\ &\cdot (\mathbf{r} + \mathbf{v}) \Big\} dl\, dm, \end{aligned} \tag{19}$$

$$\begin{aligned} &= 3V_S + 3V_H + \oint_s d\mathbf{S} \cdot \mathbf{v} \\ &+ \oint_s \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \cdot \mathbf{r}\, dl\, dm \\ &+ \oint_s \left[\frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} + \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \right] \\ &\cdot (\mathbf{r} + \mathbf{v})\, dl\, dm. \end{aligned}$$

Now the second integral on the right in this identity may be obtained from the first by interchanging the roles of $\mathbf{r}$ and $\mathbf{v}$. Thus by the divergence theorem we have

$$\oint_s \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \cdot \mathbf{r}\, dl\, dm = \int_V \operatorname{div}' \mathbf{r}\, dV', \tag{20}$$

where primes indicate that the components of $\mathbf{v}$ are to be taken as independent variables. The ordinary formula for the element of volume yields

$$dV' = J\, dV, \tag{21}$$

where J is the Jacobian $\partial(v_x, v_y, v_z)/\partial(x, y, z)$. Now let us regard $\mathbf{r}$ as a function of $\mathbf{v}$, at the same time referring both these quantities to a rectangular Cartesian system and reverting to the notation of Cartesian tensors. Then if

$$x_{i,j} \equiv \frac{\partial x_i}{\partial v_j}, \tag{22}$$

we have

$$x_{i,j} v_{j,k} = \delta_{ik}, \tag{23}$$

and hence

$$x_{i,j} = \frac{e_{ikl}\, e_{jmn}\, v_{k,m}\, v_{l,n}}{2J}, \tag{24}$$

so that

$$\begin{aligned} J \operatorname{div}' \mathbf{r} = J x_{i,i} &= \tfrac{1}{2} e_{ikl} e_{imn} v_{k,m} v_{l,n}, \\ &= \tfrac{1}{2} e_{ikl} e_{imn} (d_{km} + \tfrac{1}{2}[v_{k,m} - v_{m,k}]) \\ &\quad (d_{ln} + \tfrac{1}{2}[v_{l,n} - v_{n,l}]), \\ &= \tfrac{1}{2} e_{ikl} e_{imn} d_{km} d_{ln} \\ &\quad + \tfrac{1}{8} e_{ikl} e_{imn} (v_{k,m} - v_{m,k})(v_{l,n} - v_{n,l}) \\ &= II_d + \tfrac{1}{4} w^2. \end{aligned} \tag{25}$$

Hence (20) becomes

$$\oint_s \frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \cdot \mathbf{r}\, dl\, dm = \int_V [II_d + \tfrac{1}{4} w^2]\, dV. \tag{26}$$

To evaluate the last integral in (19) it is convenient to regard the volume V as a material volume, and the parameters l and m as material also, so that l, m, and t are independent. Then if the symbol D/Dt denote the material derivative, we have

$$\begin{aligned} \oint_s &\left[\frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} + \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m} \right] \\ &\cdot (\mathbf{r} + \mathbf{v})\, dl\, dm = \oint_s \frac{D\, d\mathbf{S}}{Dt} \cdot (\mathbf{r} + \mathbf{v}), \\ &= \frac{D}{Dt} \oint_s d\mathbf{S} \cdot \mathbf{r} - \oint_s d\mathbf{S} \cdot \mathbf{v} \\ &\quad + \frac{D}{Dt} \int_s d\mathbf{S} \cdot \mathbf{v} - \oint_s d\mathbf{S} \cdot \mathbf{a}. \end{aligned} \tag{27}$$

But since

$$\begin{aligned} \frac{D}{Dt} \oint_s d\mathbf{S} \cdot \mathbf{r} &= 3 \frac{D}{Dt} \int_V dV = 3 \oint_s d\mathbf{S} \cdot \mathbf{v}, \\ \oint_s d\mathbf{S} \cdot \mathbf{v} &= \int_V \theta\, dV, \end{aligned} \tag{28}$$

it follows that

$$\begin{aligned} \frac{D}{Dt} \int_V d\mathbf{S} \cdot \mathbf{r} - \oint_s d\mathbf{S} \cdot \mathbf{v} + \frac{D}{Dt} \int_s d\mathbf{S} \cdot \mathbf{v} \\ = 2 \oint_s d\mathbf{S} \cdot \mathbf{v} + \int_V \left[\frac{D\theta}{Dt} + \theta^2 \right] dV, \end{aligned} \tag{29}$$

and hence (27) becomes

$$\oint_S \left[\frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} + \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m}\right] \cdot(\mathbf{r} + \mathbf{v})\, dl\, dm = 2 \oint_S d\mathbf{S}\cdot\mathbf{v} + \int_V \left[\frac{D\theta}{Dt} + \theta^2 - \operatorname{div} \mathbf{a}\right] dV. \tag{30}$$

Now from (9), (5), and (6) we have

$$\begin{aligned} \operatorname{div}\mathbf{a} = a_{j,j} &= \frac{\partial \theta}{\partial t} + (v_i v_{j,i})_{,j}, \\ &= \frac{\partial \theta}{\partial t} + v_i \theta_{,i} + v_{i,j} v_{j,i}, \\ &= \frac{D\theta}{Dt} + \theta^2 - 2II_d - \tfrac{1}{2}w^2, \end{aligned} \tag{31}$$

and hence (30) becomes

$$\oint_S \left[\frac{\partial \mathbf{v}}{\partial l} \times \frac{\partial \mathbf{r}}{\partial m} + \frac{\partial \mathbf{r}}{\partial l} \times \frac{\partial \mathbf{v}}{\partial m}\right] \cdot(\mathbf{r} + \mathbf{v})\, dl\, dm = 2 \oint_S d\mathbf{S}\cdot\mathbf{v} + \int_V (2II_d + \tfrac{1}{2}w^2)\, dV. \tag{32}$$

By putting (26) and (32) into (19), we finally obtain the identity

$$V_V = V_S + V_H + \oint_S d\mathbf{S}\cdot\mathbf{v} + \frac{1}{4}\int_V (4II_d + w^2)\, dV. \tag{33}$$

Now all the foregoing analysis possesses the rather unusual quality of lacking dimensional homogeneity. We have dim $V_S = \mathbf{L}^3$, dim $V_H = \mathbf{L}^3\mathbf{T}^{-3}$, dim $\oint d\mathbf{S}\cdot\mathbf{v} = \mathbf{L}^3\mathbf{T}^{-1}$, dim $\int (4II_d + w^2)\, dV = \mathbf{L}^3\mathbf{T}^{-2}$, while V_V is not endowed with any physical dimension whatever. This deficiency in no way invalidates the result or lessens either its physical applicability or its invariance. The equality we have proved concerns *numerical magnitudes* of quantities possessing physical interpretations. The velocital volume is constructed by forming $\mathbf{r} + \mathbf{v}$, a vector having merely numerical significance and not endowed with dimensional invariance. A change of the units of length and time effects similarity transformations upon S and upon the bounding surface of V_H, while entirely changing the geometrical shape of the surface bounding V_V. Our result (33) then possesses the following property of invariance: *Whatever the choice of units, the sum of the four* numerical magnitudes *on the right is always numerically equal to the volume* V_V. Thus the dimensional inhomogeneity is indeed an advantage: it has enabled us to deduce a one-parameter family of relations (no added generality is obtained by varying both the units **M** and **T**) at a single blow.

We shall now exploit this advantage. Since the two integrals on the right in (33) are of different dimensions, for a particular choice of units the two numerical magnitudes may have a cancelling effect upon one another. In order, however, for the relation

$$V_V = V_S + V_H \tag{34}$$

to hold *irrespective of the choice of units* it is necessary and sufficient that the two integrals vanish *separately:*

$$\oint_S d\mathbf{S}\cdot\mathbf{v} = 0, \qquad \int_V (4II_d + w^2)\, dV = 0. \tag{35}$$

Hence we obtain the GENERALIZED BILIMOVITCH THEOREM[6]: *In order that the velocital volume of an arbitrary region equal the sum of its volume and its hodographic volume, for any choice of units of length and time, it is necessary and sufficient that the motion be isochoric and satisfy the further requirement*

$$4II_d + w^2 = 0. \tag{36}$$

The slightly different result which we desire here follows also from (33). We may call it the LOCAL BALANCE THEOREM: *In order that*

$$4II_d + w^2 = 0 \tag{37}$$

[6] In the work of Bilimovitch it is assumed at the outset that the motion is isochoric.

throughout the motion it is necessary and sufficient that the total flux of velocity out of any closed surface shall equal the excess of the velocital volume over the sum of the volume and the hodographic volume, whatever the choice of units of length and time:

$$\oint_S d\mathbf{S}\cdot\mathbf{v} = V_V - (V_S + V_H); \quad (38)$$

in particular, for an isochoric motion the condition becomes

$$V_V = V_S + V_H. \quad (39)$$

This theorem characterizes the class of motions in which the balance between deformation and rotation holds not merely on the average over the whole motion, but identically at each point.

PALEONTOLOGY.—*Bears from the Pleistocene Cave of San Josecito, Nuevo León, Mexico.*[1] CHESTER STOCK, California Institute of Technology.

The cavern deposit of San Josecito in southern Nuevo León, Mexico, has yielded a large assemblage of Pleistocene vertebrates of which only the birds are as yet adequately known.[2] Two types of bears have been identified recently among the fossil mammals. These represent individuals closely allied to the spectacle bears (*Tremarctos*) of South America and a member of the group of black bears (*Euarctos*) of North America.

A somewhat similar composition of the post-Pliocene ursine assemblage of Mexico was described by Freudenberg,[3] except that the tremarctine type found at Tequixquiac was identified by him as belonging to *Arctotherium simum* Cope. This is the species described by Cope and others for the Pleistocene of California and is definitely a larger type than the tremarctine bear from San Josecito Cave; it is likewise generically extinct. In addition, Freudenberg[4] describes the left jaw fragment of a black bear that he refers to the living *Ursus americanus* Pallas. The location of occurrence of this specimen, according to Freudenberg, is not known.

Thus, it appears desirable to make available at this time the new record of fossil bears at the San Josecito Cave locality, particularly since the tremarctine is identified as belonging to the Recent genus, and is the first record of the latter in Mexico.

Tremarctos mexicanus, n. sp.

Type specimen.—Calif. Inst. Tech. Vert. Paleont. Coll. No. 3933, a left ramus of the mandible with P_2 to M_3 inclusive. Associated with the type is a fragment of the left maxillary with M^1 and M^2.

Paratype.—Calif. Inst. Tech. Vert. Paleont. Coll. No. 3934, a left skull fragment with P^4–M^2.

Locality and age.—San Josecito Cave, southern Nuevo León, Mexico; Calif. Inst. Tech. Vert. Paleont. Locality no. 192. Pleistocene.

Specific characters.—Larger than living species, *Tremarctos ornatus* (Cuvier), and smaller than Pleistocene bear *Arctodus floridanus* Gidley.

DISCUSSION

The most noticeable difference between the fossil and the skulls of the Recent *Tremarctos ornatus* is in character of size, the former being larger than the largest mandible available of the living spectacle bear. Expression of this difference in size between the two is shown also by the upper teeth.

In the fossil ramus, C. I. T. no. 3933, there appears to be a greater upturn of the lower rim of the mandible below the premasseteric fossa and that below the region posterior to the fossa. There is likewise a slightly greater difference in height of horizontal ramus, as measured normal to its lower border in no. 3933, than in *T. ornatus*. The crest separating the premasseteric from the masseteric fossa is curved, but its outermost part is broken away.

In the lower jaw from the Pleistocene of Nuevo León the largest mental foramen lies below and in part in front of P_3. This position is similar to that in jaws of *T. ornatus*. A foramen

[1] Contribution No. 553, Division of the Geological Sciences, California Institute of Technology. Received July 2, 1950.

[2] MILLER, LOYE, Univ. California Publ. Zool. 47 (5): 143–168. 1943.

[3] FREUDENBERG, W., Geol. und. Paleont. Abh. (n. f.) 9 (3): 198–205. 1910.

[4] *Op. cit.*: 204–205. 1910.

of slightly smaller size is situated 11.7 mm in back of the forward opening, and lies therefore below P_4. In Recent specimens a much smaller foramen lies farther back, below the posterior half of M_1.

A longer diastema separates P_2 from P_3, and also P_3 from P_4 in the fossil than in Recent specimens. Furthermore, P_4 is relatively smaller in the fossil than in the Recent. On the whole, the characters exhibited by no. 3933 and outlined in the present comparison are to be regarded as of specific rather than of generic value.

In character of size no. 3933 is intermediate between the largest examples of the Recent *Tremarctos ornatus* in the collections of the U. S. National Museum and U.S.N.M. no. 11833, the type of *Arctodus floridanus* Gidley from the Pleistocene of Melbourne, Fla. No. 3933 from San Josecito Cave likewise agrees with *A. floridanus* in the wider spacing of the premolars, for as in the latter a longer diastema separates P_2 from P_3 and P_3 from P_4 than in *T. ornatus*. These distances are greater in *A. floridanus* than in *T. mexicanus*.

Unfortunately, the jaw is broken between the base of the canine and the posterior rim of P_2 in Gidley's type, so that no reliable measurement can be taken from the anterior end of the alveolus for P_1 to the posterior side of P_4. This distance, however, in the jaw from Nuevo León appears to be only slightly shorter in relation to the length of the lower molar series than in the species from the Florida Pleistocene. In this respect, no. 3933 is also intermediate between *A. floridanus* and *T. ornatus*. The oblique crest separating the premasseteric from the masseteric fossa reaches the anterior border of the coronoid process above the level of M_3, in which respect no. 3933 approaches *A. floridanus*, but this position is approximated in some skulls of *T. ornatus*. Though the type from Melbourne unquestionably represents a form distinct from known tremarctine bears, question may be raised with regard to its generic assignment.

Gidley[5] pointed out that "*Arctodus floridanus* is distinguished from *A. pristinus* and *A. haplodon* by its smaller size and relatively narrower molars as well as by a tendency to greater numbers of the minute tubercles of the flat triturating surfaces of the molars." The lower molars of Gidley's type are narrow transversely as in *Tremarctos* and the triturating surface of M_2 and M_3 is finely

[5] GIDLEY, J. W., Journ. Washington Acad. Sci. **18**: 432–433. 1928.

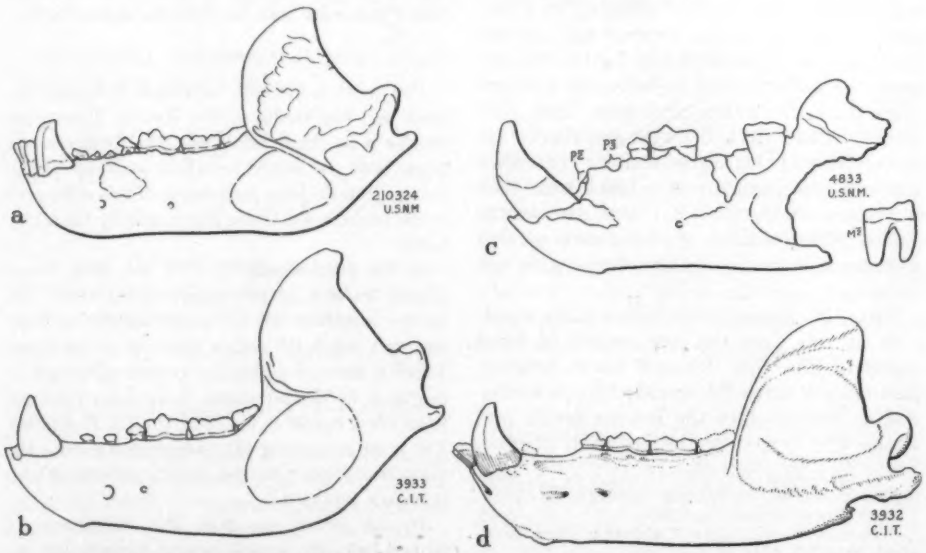


FIG. 1.—Left ramus of Recent and Pleistocene bears, lateral views, × ½: *a*, *Tremarctos ornatus* (Cuvier), Recent, Ecuador; *b*, *T. mexicanus*, n. sp., Pleistocene, San Josecito, Nuevo León, Mexico; *c*, *Arctodus floridanus* Gidley, Pleistocene, Melbourne, Fla.; *d*, *Euarctos*, near *americanus* (Pallas), Pleistocene, San Josecito, Nuevo León, Mexico.

TABLE 1.—MEASUREMENTS (IN MILLIMETERS) OF MANDIBLES OF TREMARCTOS*

Measurement	CIT 3933 Pleistocene	AMNH 67732 Recent	AMNH 42493 Recent	USNM 210323	USNM 210324	USNM 271418	USNM 171011	USNM 194309	USNM 170656	USNM 170657	*Arctodus floridanus* Type USNM 11833
Length from anterior end of symphysis to midpoint of condyle		178.3	146.4	171.0	173.8	167.7	152.0	140.0	139.0	143.0	
Length from anterior end of symphysis to angle		173.0	140.4	178.3	180.6	176.3	158.4	144.7	144.8	148.0	
Length of tooth row, anterior end of base of C to posterior end of M_3	116.2	101.0	83.1	134.7	99.4 worn	A96.2	88.8	82.9	84.7	86.7	134.7
Length, anterior end of alveolus from P_1 to posterior end of P_4	35.7	30.5	23.9	27.9	27.3	28.0	23.7	22.3	19.9	21.2	
Length from anterior end of M_1 to posterior end of M_3	56.3	51.8	44.4	51.7	54.1	50.2	47.5	45.2	49.6	48.3	62.4
Height of coronoid process above angle	97.1	83.7	68.3	80.8	85.5	79.0	71.7	63.7	69.2	68.2	
Depth of horizontal ramus at posterior end of M_3, taken normal to base of tooth row	45.6	37.8	31.7	40.4	40.3	37.8	30.9	30.4	30.1	29.5	
Depth of horizontal ramus at posterior end of P_2, taken normal to base of tooth row	38.5	34.9	29.5	35.4	38.1	35.1	29.7	26.3	27.6	27.5	A44.8
C, anteroposterior diameter at base of crown	19.6	16.8	13.6	16.5	A16.1	16.0	14.4	13.7	14.0	15.6	21.0
C, transverse diameter at base of crown	12.4	10.6	8.8	11.2	11.5	10.5	9.9	8.9	9.5	9.1	14.3
P_2, anteroposterior diameter	5.1	5.5	3.1	5.4		5.3	4.7	4.6	4.5	4.4	
P_2, transverse diameter	3.3	3.7	2.5	3.5		3.3	2.9	2.9	2.9	3.6	
P_3, anteroposterior diameter	4.8	5.5	3.2	4.7		5.4	4.5	4.6	4.8	5.0	
P_3, transverse diameter	3.0	4.0	2.5	3.4		3.8	2.9	3.1	3.1	3.0	
P_4, anteroposterior diameter	7.9	8.2	7.6	9.1	8.0	8.5	6.9	7.0	7.4	7.8	9.2
P_4, transverse diameter	4.6	5.9	4.5	5.6	5.6	5.6	5.0	4.7	5.3	5.4	5.6
Length of diastema between P_2 and P_3	5.4	2.0	1.4	9.1	1.9	2.0	2.0	1.3	1.2	1.2	
Length of diastema between P_3 and P_4	6.6	2.2	1.2	5.2	2.0	1.6	2.4	1.1	1.5	0.6	
M_1, anteroposterior diameter	20.0	18.9	16.4	22.3	20.0	19.2	17.5	17.3	18.7	18.0	22.4
M_1, greatest transverse diameter	9.3	9.6	7.8	11.2	10.5	9.3	8.5	8.6	8.8	9.1	11.2
M_2, anteroposterior diameter	20.8	18.4	16.8	19.2	19.9	18.0	18.3	16.9	18.3	17.2	
M_2, transverse diameter	12.1	11.7	10.0	9.8	12.1	11.5	10.8	10.0	11.4	11.0	
M_3, anteroposterior diameter	14.6	14.7	12.3	13.6	14.7	12.7	11.8	11.1	13.3	12.6	
M_3, greatest transverse diameter	11.6	10.9	9.0	11.1	12.1	11.1	10.1	8.9	10.0	10.0	

* With exception of nos. 3933 and 11833, specimens belong to living species, *Tremarctos ornatus* (Cuvier).
A, approximate.

crenulate or tuberculate as in the South American bear. The resemblance between the two extends to the location of many of the individual tubercles, which in some specimens can be identified as having the same position in both the fossil and Recent teeth. These resemblances are therefore regarded as further evidence supporting the view that the tremarctine bear from the Pleistocene of Florida is more closely related to *Tremarctos* than to *Arctodus*. Furthermore, it is the largest known species of *Tremarctos* in the former extension of range of the genus from South America into Mexico and Florida. The following additional measurements of the fossil specimens are pertinent in connection with the latter range in size:

	No. 3933 Nuevo León	*No. 4833 Florida*
M^1, anteroposterior diameter along inner side	17.3	19.3
M^1, transverse diameter across posterior third of tooth	13.8	16.1
M^2, anteroposterior diameter	27.6	31.1
M^2, transverse diameter across protoconid	14.6	16.2

In addition to the striking differences in the construction of the lower jaw in *Tremarctos* and *Euarctos*, shown by the presence in the former and absence in the latter of the premasseteric fossa, differences are likewise seen in the lower posterior portion of the ramus. The inferior border is much more curved in *Tremarctos* and sweeps directly to its posterior terminus, the angular process. In *Euarctos*, on the other hand,

TABLE 2.—MEASUREMENTS (IN MILLIMETERS) OF SKULLS OF TREMARCTOS*

Measurement	CIT 3934 Pleisto-cene	AMNH 67732 Recent	AMNH 42493 Recent	CIT 3933 Pleisto-cene	USNM 210323 Recent	USNM 210324 Recent	USNM 271418 Recent	USNM 171011 Recent	USNM 194309 Recent	USNM 170656 Recent	USNM 170657 Recent
Length of tooth row, C to posterior end of M^2	110.0	89.5	75.0		88.4	88.8	*A*88.8	80.7	72.9	72.1	78.8
Length from anterior end of alveolus of P^1 to posterior end of M^2	84.1	69.7	59.0		67.9	69.1	*A*66.9	62.6	56.9	57.8	61.0
Length from anterior end of M^1 to posterior end of M^2	46.6	41.6	35.7		41.0	42.7	41.9	38.0	35.1	36.3	38.1
C, anteroposterior diameter at base of crown	19.5	*A*17.5			17.3	18.5	*A*19.3	16.0	14.1	15.2	15.3
C, transverse diameter at base of crown	12.1	11.2			12.0	12.0		10.2	8.7	9.6	8.9
P^1, anteroposterior diameter		6.9	5.3		6.1	6.9	5.6	5.8	5.6	5.2	6.1
P^1, transverse diameter		4.3	3.8		4.1	4.5	4.4	4.0	3.8	3.7	3.9
P^2, anteroposterior diameter of crown		5.1	5.0		4.8	5.7	4.1	4.8	4.6	4.5	4.4
P^2, transverse diameter of crown		3.2	3.2		3.4	3.4	3.3	2.8	3.0	2.3	2.9
P^3, anteroposterior diameter of crown		4.3	3.7		6.5	5.4	5.3	4.9	4.9	5.1	4.9
P^3, transverse diameter of crown		3.4	2.6		3.8	3.4	3.4	3.0	3.1	3.3	2.9
P^4, anteroposterior diameter along outer side	14.2	13.7	11.0		12.7	13.5	12.3	11.2	11.3	11.9	11.2
P^4, transverse diameter across protocone	11.4	9.6	7.0		9.8	9.6	9.1	8.1	8.2	8.4	8.2
M^1, anteroposterior diameter	18.2	16.7	14.8	*A*17.5	17.3	18.1	16.9	15.7	15.9	16.1	15.5
M^1, greatest transverse diameter	14.5	12.8	11.2	*A*13.6	13.6	14.7	14.0	11.6	12.5	11.9	11.7
M^2, greatest anteroposterior diameter	28.9	24.3	20.9	27.9	23.7	25.6	24.7	22.2	21.0	20.9	22.2
M^2, greatest transverse diameter	14.8	13.8	11.9	14.5	13.7	14.5	14.2	12.9	12.5	12.6	12.8
Length from anterior end of premaxillary to middle of rim of postnarial notch					115.4	117.9	108.7	104.7	91.0	89.9	98.3

* With exception of no. 3934, specimens belong to Recent species, *Tremarctos ornatus* (Cuvier).
A, approximate.

the inferior border ends well in front of the angle, and a break in the form of a notch on the lower contour of the jaw separates it from the angular process. The latter is much more prominent in *Euarctos* than in *Tremarctos* (compare Fig. 1, *a* and *d*).

In the jaw of the tremarctine bear the vertical distance between angle and condyle, as seen from the rear, is distinctly greater. In the Recent *Tremarctos* a rudimentary process may sometimes occur on the inferior border of the ramus below the true angle, but in no. 3933, as in many existing specimens, the border swings smoothly upward along the inside of the thickened ventral surface. The absence of a projection at the posterior end of the ventral border of the ramus in *Tremarctos* and its distinctness from the angle furnish additional striking differences between this genus and *Euarctos*.

Euarctos, near americanus (Pallas)

The North American black-bear group is represented in the collection by a left ramus of the mandible, Calif. Inst. Tech. Vert. Paleont. Coll. no. 3932. Comparing the specimen with jaws of the living black bear brings out the fact that the essential difference between them relates to the larger size of the molar teeth in the fossil. Other than this character, and increased size of lower canine, resemblance prevails between the available materials of the Pleistocene and Recent bears.

TABLE 3.—MEASUREMENTS (IN MILLIMETERS) OF C.I.T. No. 3932

Length, anterior end of symphysis to posterior end of angle	201.0
Length, anterior end of symphysis to posterior end of middle of condyle	193.9
Height of coronoid process above angle	85.5
Length, anterior end of base of C to posterior end of M_2	100.2
Length, anterior end of P_4 to posterior end of M_2	51.0
Depth of jaw at posterior end of M_2	41.6
P_4, anteroposterior diameter	10.4
P_4, transverse diameter	5.7
M_1, anteroposterior diameter	19.3
M_1, greatest transverse diameter	9.7
M_2, anteroposterior diameter	21.7
M_2, greatest transverse diameter	13.1

Schultz,[6] in describing the species *Ursus optimus* from the Pleistocene asphalt deposits of McKittrick, Calif., called attention to the relatively larger molar dentition which distinguished this Pleistocene form. It should be indicated that the canine is likewise of larger size in the bear from McKittrick than in the modern species.

The scarcity of remains of black bears does not permit a demonstration of the extent of variation in size of the form from the Pleistocene. The jaw from San Josecito Cave is smaller than that of *U. optimus*, but like the latter it shows an increase in size of the molars, although this increase is not so great as in the Californian individual. It seems possible that the Mexican bear is a member of the group typified by the McKittrick specimen and characterized by greater range in size than is found to be true of *Euarctos americanus* today.

[6] SCHULTZ, J. R., Carnegie Inst. Washington Publ. 487: 178–181, pl. 11. 1938.

PALEOBOTANY.—*An Oligocene evergreen cherry from Oregon.*[1] ROLAND W. BROWN, U. S. Geological Survey.

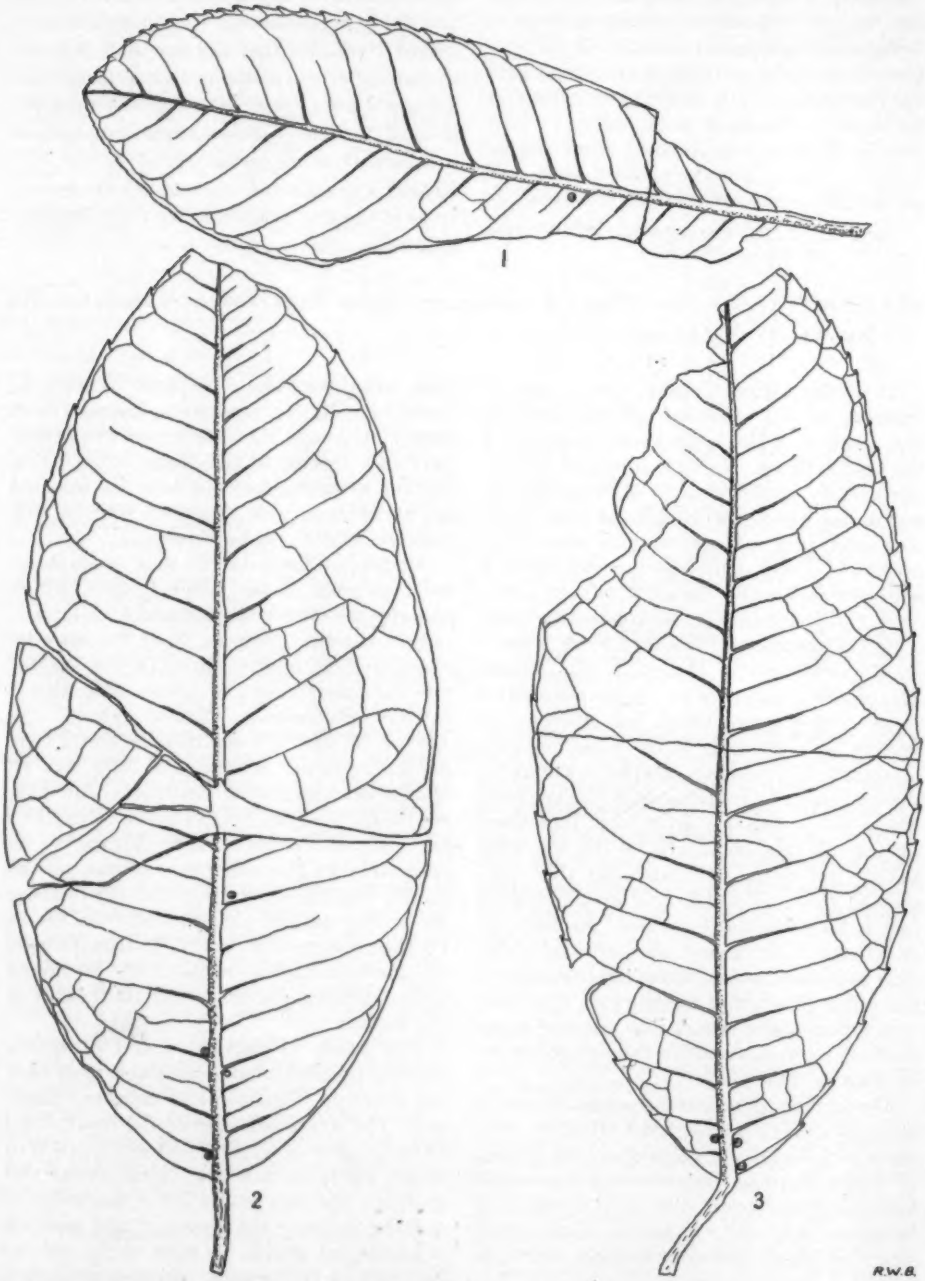
At Holley, Linn County, Oreg., marine fossils from rock outcrops indicate the relative position of the easternmost shoreline of the Oligocene sea. North and east of Holley, particularly in the vicinity of Sweet Home, nonmarine exposures in railroad cuts, highway cuts, and ravines, contain beautifully preserved leaves, fruits, seeds, and wood of land plants. Locally the wood is very abundant, the dominant species apparently being a kind of sycamore (*Platanus*). From a locality 12 miles east of Holley, L. W. Staples (*4*), of the University of Oregon, described some of this wood, which has the unusual feature of containing cubic pseudomorphs of quartz after halite. Staples interpreted these crystals as meaning that the lowlands where the sycamores grew were inundated by the advance of an arm of the sea, thus killing the trees. Salt solutions then permeated the dead trunks and at appropriate foci halite crystals developed, pushing the wood cells aside. Eventually, alluvial materials and volcanic ash buried the trees, ended the saline phase, and inaugurated the freshwater percolation conditions for dissolving the halite crystals and for the concentration of silica in their place.

My introduction to this geologic situation occurred during August 1949, when, in company with Dr. H. E. Vokes and Don Myers, of Johns Hopkins University, I made collections of the fossil flora at a number of localities near Sweet Home. Subsequent study of these collections shows that the flora includes species of sequoia, hydrangea, laurel, sycamore, sweetgum, katsura, and cherry. Although the cherry may not be the only new species in this flora, it is singled out for attention here because its remains are particularly well preserved, showing distinctive, identifying features.

Numerous fossil leaves and seeds have been assigned to the genus *Prunus*, which includes the cherries and plums. Of all these, only a handful, perhaps 20 or 30, may be considered authentic. Most of the species are leaf-species, and of these, only two—*Prunus aucubaefolia* Massalongo (*2*, p. 415, pl. 28, fig. 2), from Miocene strata near Senigallia on the east coast of Italy, and *P. laurocerasus pliocenica* Laurent (*1*, p. 179, pl. 14, fig. 4), from the Pliocene of the Department of Cantal, France—appear to be assignable to the evergreen section of the racemed species of *Prunus*. Neither of these shows any glands. Consequently, so far as I know, the present specimens from Oregon are the first known fossils of the evergreen group showing glands within the blades of the leaves.

The leaves of deciduous and evergreen cherries are somewhat comparable in at least two features—venation and marginal dentition. The evergreen species, however, tend to be tougher in texture, and less toothed or entire, the teeth, as a rule, being coarser and sharper. The two groups differ markedly in another respect—the presence and position of prominent glands. In most of the deciduous cherries one or more conspicuous glands are present on the petiole, near its top. In

[1] Published by permission of the Director, U. S. Geological Survey. Received July 2, 1950.



FIGS. 1–3.—*Prunus pristina* Brown, n. sp. Natural size.

the evergreen species, on the other hand, the few glands, if present, flank the midrib, either closely or distantly, in the basal part of the leaf-blade. The glands of one well-known species, *Prunus ilicifolia* Walpers, of California, are usually restricted to the basal margin. The function of these glands is unknown to me, but if the reader is interested in the general subject he may consult Sachs (*3*, pp. 183–186).

Other families of plants than the Rosaceae may have species that develop glands. In the tree-of-heaven (*Ailanthus altissima* Swingle), of the Simarubaceae, the tips of the large, basal teeth of the leaflets are prominently glandular and afford a ready means of identifying the tree. The marginal teeth of the poplars, willows, and many other trees may also be gland-tipped. The popular hedge plant, privet (*Ligustrum vulgare* Linnaeus), of the Oleaceae, has entire, opposite leaves that are glandular in the manner of the evergreen cherries. So also are the leaflets of *Trichilia*, of the Meliaceae. Minute, glandular dots, usually emitting aromatic odors, are sprinkled liberally over the leaves of the St. Johnsworts (Hypericaceae), eucalypts (Myrtaceae), oranges (Rutaceae), loosestrifes (Primulaceae), cottons (Malvaceae), wood-sorrels (Oxalidaceae), and many others.

ROSACEAE

Prunus pristina Brown, n. sp. Figs. 1–3

Leaves elliptic or slightly oblanceolate in outline, with cuneate bases and rounded to blunt pointed apexes, attaining a length of 15 cm and width of 6 cm. Margins coarse-serrate in whole or in part, or in some instances entire, the sinuses between the teeth scalloped. From the prominent midrib, at wide angles, arise equally-spaced, strong, camptodrome, secondary veins that make angular loops near the margins with the veins above. From these loops short veins run into the teeth. Between the secondaries are short intersecondaries that also arise from the midrib. Diagonal tertiary veinlets connect the secondaries and intersecondaries. Characteristic rounded glands of nearly uniform size, but displaying no further identifying details, are present in the basal halves of some of the leaves near the midrib. Many leaves are without glands. Scattered over these leaves, as in most fossil leaves, are also rounded spots of differing size that were caused by fungi, insects, or other agents. These must not be confused with the glands. Petiole stout, 2 cm long or more. No seeds recognizable as those of *Prunus* were found.

Locality: Along the T. Fell farm lane, in sec. 17, T. 13 S., R. 1 E., about 2¼ miles northeast of the bridge over the Santiam River at Sweet Home, Oreg. Specimens in the U. S. National Museum.

These leaves, at first sight, may be compared with the tough leaves of the Pacific madrone (*Arbutus menziesi* Pursh), of the Ericaceae, and particularly with those of the toyon (*Photinia arbutifolia* Lindley), of the Rosaceae. Although the madrone can be rejected at once by reason of its more diffuse secondary venation and finer, sharper teeth, when these are present, the toyon is more difficult to eliminate as a possible reference for the fossil leaves, because the venation and teeth of its leaves are more closely comparable to those of the fossils. However, in well-developed, large leaves of the toyon the secondary veins have a tendency to fork near the margin and one or both of these forks run directly into the marginal teeth. Moreover, the toyon has no glands.

The closest match I have so far found for the fossils among living species is *Prunus laurocerasus* Linnaeus and its varieties. This evergreen laurel-cherry is a native of southeastern Europe and southwestern Asia, ranging into northern Persia. It is cultivated in the United States at least as far north as Washington, D. C., and Roseburg, Oreg., where I have seen it. One of its associates in its native haunts is *Zelkova ulmoides* Schneider, a living representative of an ulmaceous genus that had a number of characteristic species in the western United States during the greater part of the Cenozoic era. Not any of these, however, has yet been found in the Oligocene localities at Sweet Home.

The native, evergreen cherries of the United States, Mexico, and the West Indies—*Prunus caroliniana* Aiton, *P. ilicifolia* Walpers, *P. lyoni* (Eastwood) Sargent, *P. azitliana* Standley, *P. brachybotrya* Zuccarini, *P. prionophylla* Standley, *P. myrtifolia* (Linnaeus) Urban, and others—fail, in one respect or another, to satisfy the requirements of reasonable identity with the fossils, and I conclude that *Prunus pristina* is not closely related to any of them.

Considering the associates of *Prunus pristina*—sequoia (of the coast redwood kind), hydrangea,

sycamore, and sweetgum—I can visualize a valley lowland situation, perhaps not far from the sea. It was a well-watered land with a genial climate that did not have severe winters.

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BOTANY.—*New combinations in southwestern* Salix.[1] CARLETON R. BALL, U. S. Department of Agriculture.

In preparing treatments of the genus *Salix* for certain manuals of botany, and for a final monograph, I find that the changes in status require publication and discussion. The descriptions permitted in most manuals are too brief to acquaint students with novelties, and adequate discussion and citation of specimens are impossible.

1. **Salix gooddingii** Ball and Its Glabrous-capsuled Variety

Salix gooddingii was published in 1905 (Bot. Gaz. **40**: 376), based on *Goodding 689* from what is now Clark County, Nev. This was a somewhat immature, partially insect-parasitized, and unusually pubescent specimen. Misled by foliar immaturity, and by the dense pubescence of both vegetal and pistillate floral organs, I assigned the new species wrongly to section *Longifoliae* (sandbar willows) instead of to section *Nigrae* (black willows). A specimen that should have been made the staminate type, *Goodding 719*, was overlooked entirely. These two errors were brought to my attention later by Prof. W. W. Rowlee and were acknowledged in a second paper on *S. gooddingii* (1921). That early experience taught me never again to base a new species on a single collection, a fact well worth learning.

In the paper of 1921, the species was redescribed and was illustrated by 3 photographs of Colorado Valley trees. The description was broadened to include in the species the glabrous-capsuled expression of the plant, as Schneider had done in 1918 and 1919. When accumulating material of both forms indicated that the glabrous-capsuled plant should be recognized as a variety, it was assumed that *S. nigra* var. *vallicola* Dudley (in Abrams, *Flora of Los Angeles and vicinity*: 100. 1904) represented this variety. Abrams had described the capsules as "glabrous or more or less pubescent." Britton, in raising Dudley's variety to specific rank as *S. vallicola* (Dudley) Britton (in *North American trees*: 184. 1908), described the capsules simply as "glabrous." The writer overlooked the fact that, in spite of these descriptions, the type specimen Abrams had cited (*Abrams 3256*, from Orange County, Calif.) actually had pubescent capsules. Under taxonomic rules, the type specimen, rather than the published description, governs the application of a name. Hence, both *S. nigra* var. *vallicola* Dudley and *S. vallicola* (Dudley) Britton are synonyms of *S. gooddingii* Ball.

Because of the erroneous assumption that var. *vallicola* was a glabrous-capsuled variation, large numbers of collections with glabrous ovaries and capsules have been determined as *S. gooddingii* "var. *vallicola* (Dudley) Ball," but, by oversight, that combination never has been published. In consequence of this series of errors, it now becomes necessary to publish this variety under a new and different name.

Salix gooddingii Ball var. **variabilis**, n. var. A specie differt ovariis capsulisque glabris. Distinguished from the species by ovaries and capsules glabrous. In the species, the ovaries are always more or less densely pubescent and the young capsules also are pubescent, but in age the capsules tend to become glabrate or glabrous.

The pubescence or puberulence of vegetal organs (twigs, budscales, petioles, midribs, and blade bases) is variable in both variety and species. In general, these organs in the typical form are more pubescent and retain the hairiness longer. In the variety they usually are pubescent or puberulent only while young and generally become glabrate soon and entirely glabrous later. However, exceptions occur in both species and variety. Hairiness varies with the stage of de-

[1] Received July 10, 1950.

velopment of the various organs. Staminate specimens add to the difficulty of determination, as they have no ovaries or capsules to reveal pubescence. They must be assigned to the species or to the variety accordingly as one or the other occurs exclusively or commonly in the locality. More abundant hairiness probably is influenced by the higher temperatures characteristic of the more southern latitudes and lower altitudes occupied by the species. Although no hard and fast lines can be drawn between species and variety, the wide difference between the more extreme expressions still indicate that a varietal separation should be helpful to students.

Both species and variety are found commonly as shrubs to small or midsized trees 7–40 feet (2–12 meters) tall. Larger trees of both, 50–60 feet (15–18 meters) high, are found throughout their ranges, and very large trees, 70–80 feet (21–24 meters) in height, occur occasionally. The combined range of the two is from southern California eastward to western Texas, including adjacent Mexico and southern Utah and Nevada, with a long finger extending northward through the Central Valley of California as far as Shasta County.

Typical *S. gooddingii* has its most abundant and practically exclusive distribution in the lower part of the Colorado River Valley. This area extends southward from Washington County in southwestern Utah and Clark County in southeastern Nevada through the western parts of Mohave and Yuma Counties in Arizona, and the eastern parts of San Bernardino and Riverside Counties and all of Imperial County in California, to the Gulf of California in the States of Sonora and Baja California in adjacent Mexico. The variety is practically absent from this area. The species extends sparingly westward, with the variety, to Orange and San Diego Counties of California and western Baja California in Mexico. Northward, it occurs more sparingly, with the abundant variety, in the Central Valley of California to Kern and Fresno Counties, with one known occurrence in Yolo County.

S. gooddingii occupies an area of relatively low base level. It occurs at sea level to as much as 150 feet below in the Salton Sink of Imperial County. Throughout its range in southern California and adjacent Arizona and Mexico, and also in the Central Valley, it occurs at elevations of only a few hundred feet. In the mountains of these areas, however, it may reach elevations of 2,000 feet (600 meters) and rarely to 2,800–3,000 feet (840–900 meters) in Nevada and Utah.

Variety *variabilis*, on the other hand, is absent or relatively rare in most of this area of low base level, although it occurs at sea level or below in the Death Valley of Inyo County and commonly at altitudes of a few hundred feet in the Central Valley as far north as Shasta County, Calif. Its large area of exclusive occurrence is eastward across Arizona, southern Utah, New Mexico, and western Texas, with adjacent portions of the States of Sonora and Chihuahua in Mexico. In the mountains of these States it ascends to 4,500 or 5,000 feet (1,350–1,500 meters) and rarely to 5,500 or 6,500 feet (1,650 or 1,950 meters) in southern Arizona.

SPECIMENS CITED. For the western area, where both species and variety occur, it seems desirable to cite specimens of each. Those listed are in the following herbariums: Carleton R. Ball (CRB); U.S. Forest Service (FS); and U.S. National Herbarium (USN). Where the labels bear collection numbers the date is not cited here, except in some cases where the same numbers were used in successive years. For convenience of students, the specimens are listed by counties in each State, as counties are shown on most maps whereas many creeks, small lakes, canyons, mountains, and small towns are not. The full name of the collector is given in the first listing and only the surname thereafter. Specimens of the species are cited first, then those of the variety. Listings are from east and south to west and north.

Salix gooddingii. ARIZONA. Yuma County: Yuma, *Carleton R. Ball 1740* (old capsules glabrous), *1901* (old capsules pubescent) (both CRB, USN); Yuma Desert, *Aven & Ruth A. Nelson 1291* (USN); Yuma, E.O.Wooton, April 21, 1913 (USN). Yuma-Mohave County Boundary: Alamo Crossing of Bill Williams River, *Leslie N. Goodding Sal.-88*, in 1938 (CRB). Mohave County: Topock, Colorado River, *E.A. Goldman 2970* (USN); Willow Beach, Black Mountains., *Russell K. Grater S 1, S 2, S 3*, in 1938 (CRB); 8 miles above Pierce's Ferry, *Marcus E. Jones 5077 u* (USN); Beaver Dam Wash Beaver Dam (Littlefield), *Constant H. Robinson 39* (CRB); near Petrified Springs, Littlefield, *Ivar Tidestrom 9236* (CRB, USN). County unknown: Beaver Creek (several in Arizona); B. E. Fernow, August 1896 (USN, as *S. fluviatilis*).

UTAH. Washington County: St. George, alt.

900 meters, *W. W. Eggleston 14773* (USN); Leeds, *Goodding Sal.-17*, in 1938 (CRB, not var. *vallicola* as determined); Virgin River 3 miles northwest of Hurricane, alt. 2,800 feet, *Bassett Maguire & H.L. Blood 1317, 1317a* (CRB); along Santa Clara Creek, St. George, *Tidestrom 9276* (USN).

NEVADA. Clark County (formerly part of Lincoln County): Muddy Creek (River), *Goodding 689*, in 1902 (CRB, pist. type); Rioville, Colorado River, *Goodding 719*, in 1902 (CRB, stam. type; USN); Muddy Creek ("Lincoln County"), *P. B. Kennedy & Goodding 41* (CRB); Bunkerville, *Tidestrom 9200* (USN), *9202* (CRB, USN).

CALIFORNIA. Imperial County: Near Calexico, G. O. Abrams, April 1910 (USN); end of ferry, Fort Yuma, *Ball 1941* (CRB); 22 km north of Brawley, *Mrs. H. P. Bracelin 609* (CRB); near bridge over New River, 7.5 meters below sea level, *Bracelin 611, 612* (CRB); 6.5 km west of Calexico, *Bracelin 613* (CRB); Colorado River, Yuma Indian Reservation, *Agnes Chase 5517* (CRB, stipules glandular, fragrant); U.S. Field Station, Bard, *Goodding & Charlotte Goodding Reeder 40* (CRB); San Bernardino Ranch (Mexican Boundary Line), *Edgar A. Mearns 735, 1992* (USN); San Pedro River (same), *Mearns 1110* (USN); San Bernardino River (same), *Mearns 2543* (USN); Fig-Tree John's Spring, Salton Sea, 150 feet below sea level, *Munz, Street, & Williams 2342* (USN); Salton Basin, *S.B. Parish 8092a* (CRB); Unlucky Lagoon (Mexican Boundary Commission), *L. Schoenfeldt 2918* (USN); Bard, *H.L. Westover 1, 2*, in 1913 (CRB, USN); *Westover 3*, in 1919 (USN). San Diego County: Bernardo, San Dieguito River, *LeRoy Abrams 3371* (USN); Pine Valley, *Mearns 3977* (USN). Orange County: Santa Ana River, near Orange, *Abrams 3256* (USN); Rancho Santa Ana, near River, *Carl B. Wolf 2950, 2955* (CRB). Riverside County: Cameron Lake, Colorado Desert, T.S. Brandegee, March 28, 1901 CRB); Thousand Palms, Carl Epling, March 27, 1927 (CRB); 1000-Palm Canyon, Colorado Desert, *H. De Forest 1*, in 1932 (CRB); north of Elsinore, *Philip A. Munz 12032* (USN); near State Inspection Station, on way to Blythe Bridge, *Wolf 3035* (CRB). San Bernardino County: Beside Mohave River, 1.5 km north of Barstow, *Bracelin 587, 588* (CRB); Fort Moh(ave), J.G. Cooper, March 25, 1861 (CRB, USN); along Mohave River, Cooper (USN, without other data); San Bernardino, *P.B. Kennedy 1672* (CRB); Colton, *Jones 3195* (USN); Santa Ana River, San Bernardino, *Alfred Rehder 165* (USN); near Mohave River, 5 miles west of Barstow, *W. A. Setchell & Victor Duran 10* (CRB); Barstow, *Tidestrom 9687* (USN); San Bernardino, *George R. Vasey 566* (USN). Kern County: Beside Old River Road, 32 km southwest of Bakersfield, *Bracelin 576, 577* (CRB). Fresno County: San Joaquin River at Friant, *Albert E. Thompson 1012* (CRB). Yolo County: River bank near Madison, *A. A. Heller 5419* (USN).

MEXICO. Baja Calfiornia: Seven Hills, on the Salton River, *Mearns 2869, 2877* (USN, stam.).

Variety *variabilis*. UTAH. Grand County: Moab, *Goodding Sal. 33, Sal. 39*, in 1933 (CRB). San Juan County: Augusta Natural Bridge, 48 miles west of Blanding, *Goodding Sal. 33*, in 1939 (CRB); San Juan River, 2 miles east of Mexican Hat, *Maguire 20167* (CRB). Washington County: Arizona Strip, *Bernell McAllister 60* (CRB); Zion National Park, *A. M. Woodbury 30* (USN). County unknown: Frement's Expedition to California, 1845–47 (USN, in ink on label is "Utah"; in faint pencil is "402a. Calif.").

NEVADA. Nye County: Ash Meadows, *F. V. Coville & Frederick Funston 2145* (USN).

CALIFORNIA. San Diego County: San Luis Rey River bottoms, southeast of Bonsall, *Chas. B. Fiker 3349B* (CRB). Riverside County: Near spring at Twentynine Palms, Colorado Desert, *Clary Herbarium 920* (CRB); Palm Canyon, *Ivan Johnston 1056* (USN); north of Elsinore, *Munz 12032* (CRB); Diablo Canyon, near Clary's Coral Reef Ranch, Colorado Desert, *Carl W. Sharsmith 14* (CRB). San Bernardino County: Along Mohave River, Helendale, *Bracelin 590, 593* (CRB); Barstow, Frank W. Johnson, April 23, 1910 (USN). Inyo County: Mitchell Ranch, Resting Springs Valley, *Coville & Funston 262* (USN); Furnace Creek Ranch, Death Valley (cultivated), *Coville & Funston 469* (USN); Big Spring, Shoshone, *Coville & M. French Gilman 454* (USN); Black Rock Springs, *Mark Kerr 96* (CRB).

CENTRAL VALLEY OF CALIFORNIA. Kern County: Tulare Plains about 10 miles south of Bakersfield, *Coville & Funston 236* (USN). Tulare County: Hanford, *Alice Eastwood 3846, 3851* (USN); Visalia, *Eastwood 34* (USN); Kaweah River, between Ash Mountain and Three Rivers, *Harold E. & Susan T. Parks 01037, 01070, 01071* (USN) (all CRB); Kaweah River north of Visalia, *Thompson 1042* (CRB). Fresno County: Fresno, *George L. Fisher 79* (USN);

Centerville, Kings River Delta, *H. E. Parks 0932* (CRB); beside San Joaquin River at Friant, *Thompson 1013* (CRB). Madera County: Fresno River, J. W. Congdon, June 21, 1903 (USN); Power House 1, San Joaquin Forest, Ernest G. Dudley, November 1911 (CRB); shore of Bass Lake (Reservoir), alt. 3,400 feet, *Thompson 1063* (CRB). Merced County: East of Los Banos, *Bracelin 702* (CRB). Stanislaus County: Denair, *Paul A. Harvey 1, 3*, in 1940 (CRB). San Joaquin County: Tom Payne's or Paradise Cutoff, Tracy Pike, about 15 miles south of Stockton, *Ball 1929* (CRB, USN). County unknown: Sacramento Valley, U. S. Exploring Expedition under command of Capt. Wilkes (USN, no date). Sacramento County: Sacramento, *Lester F. Ward 89* (USN). Amador County: Sutter Creek, Ione, *C. H. Merriam 4*, in 1905 (USN); South Jackson, *George Hanson 198* (USN). Yolo County: Rumsey, *C. F. Baker 2936* (USN). Nevada County: Penn Valley, west of Grass Valley, *Heller 13183* (USN). Lake County: Shore of Clear Lake in Highland Park, *Milo S. Baker 5351, 5357* (CRB); bank of Cache Creek, *H. N. Bolander 2678* (USN); near Clear Lake, *John Torrey 490* (USN). Butte County: near U. S. Rice Experiment Farm, Biggs, *Ball 1820* (USN), *1821* (USN), *1822, 1824, 1839* (all CRB); along Chico Creek, Chico, *Ball 2069, 2071, 2072* (CRB, USN); Chico-Oroville Road, 12 miles from Chico, *Heller 11262* (USN). Tehama County: Red Bluff, *L. E. Smith 596, 599, 600, 668, 669* (all USN): Shasta County Redding, bridge at north end of town, *Bracelin 481* (CRB, USN); Reed Creek, *Smith 610* (USN).

MEXICO. Baja California: La Paz, *Edward Palmer 77*, in 1890 (USN, as *S. bonplandiana*); Gardener's Laguna, *L. Schoenfeldt 2895*, in 1894 (USN). State uncertain: Lake Polonius (?), Mimbres Valley, *Mearns 184*, in 1892 (USN). Sonora: Alamo, near Magdalena, *Kennedy 7030*, in 1925 (USN); vicinity of Hermosillo, *Rose, Standley, & Russell 12391, 12501*, in 1910 (USN); vicinity of Navajoa, *Rose et al. 13156*, in 1910 (USN); vicinity of Magdalena, *Rose et al. 15113*, in 1910 (USN); Río Bavispe, near Colonia Oaxaca, *Stephen S. White 428*, in 1938 (CRB); Arroyo Carretas, Carretas, border of Chihuahua and Sonora, Municipio de Janos, *White 2615*, in 1939 (CRB); Río Bavispe, Bavispe, *White 2881*, in 1940 (CRB); Horconcitos, Río Hauchinera (Río de Bavispe area), *White 2973*, in 1940 (CRB); Río Fronteras, San Rafael, *White 3862*, in 1941 (CRB); Colonia Morelos, *White 4102*, in 1941 (CRB). Chihuahua: Southwest of San Ysidro, Dist. Guerrero, *Ynes Mexia 2534*, in 1929 (CRB); Santa Eulalia Mountains, Wilkinson, in April 1888 (USN). *White 2615 and 4102*, listed above in Sonora, may possibly be from adjacent Chihuahua.

Bibliography.—Because the material comprising *S. gooddingii* and its variety *variabilis* has been presented and discussed under so many different names, it seems desirable to give a fairly full bibliography of these treatments. Where these publications cover southern or central California and the adjacent portions of Nevada, Arizona, and Mexico, they may be discussing either the species or the variety, or both.

S. gooddingii n. sp., Ball, Bot. Gaz. **40**: 376. 1905; Ball, Bot. Gaz. **72**: 227–234, *figs. 2–4*. 1921; Schneider, Bot. Gaz. **65**: 12–13. 1918; Schneider, Journ. Arnold Arb. **1**: 9. 1919; Tidestrom (*Flora of Utah and Nevada*), Contr. U. S. Nat. Herb. **25**: 135. 1925; Baker, *Partial list of seed plants of the North Bay Counties:* 22. 1934, rev. ed. 28. 1945 (mimeographed); Goodding (*Willows in Region VIII*), U. S. Dept. Agr. Soil Cons. Serv. Reg. Bull. **66**: 6–7, *4 illus.* 1940; Kearney and Peebles (*Flowering plants and ferns of Arizona*), U. S. Dept. Agr. Misc. Publ. **423**: 219. 1942; Little (*Checklist of the native and naturalized trees of the United States*), U. S. Dept. Agr. For. Serv. (mimeographed): 263. 1944.

S. nigra, as interpreted by numerous authors,[2] not Marshall, in floras and forest floras of varying geographic coverage, so far as these apply to southwestern areas from western Texas westward. These works are not cited here in full, only author and year being given. For better understanding, they are grouped by size of area covered, as local, State-wide, regional, and national. Coulter, *Botany of western Texas*, is listed as regional because of the large area covered. *Local:* Greene, 1894; Hall and Hall, 1913; Jepson, 1901, 1911; Merriam, 1893; Parish, 1913. *State-wide:* Bebb, 1879 and 1880; Eastwood, 1905; Jepson, 1909, 1909, 1910; Wooton, 1913; Wooton and Standley, 1915. *Regional:* Coulter, 1894; Howell (Thomas), 1902; Sudworth, 1908. *National:* Sargent, 1896, 1905; Sudworth, 1897, 1898.

S. nigra Marsh., var. *vallicola* Dudley, in Abrams, *Flora of Los Angeles and vicinity:* 100. 1904, and

[2] In 1921 I used the commonly accepted but both inaccurate and misleading form of citation: "*S. nigra* of numerous authors, not Marsh." when I should have written: "*S. nigra*, as interpreted by numerous authors, not Marsh." Schneider, in 1918 and 1919 (l.c.), similarly had ascribed the publication of an "*S. nigra*" to each of nine authors, when they merely were wrongly interpreting *S. nigra* Marshall. The same error was repeated by me in 1923 (in Abrams, *Illus. Flora of the Pacific States* **1**: 490).

suppl. ed. 100. 1911; Jepson, *Man. Flowering Pl. Calif.* 263. 1925; Pickwell and Sayle (*Trees of valley and foothill*), in West. Nature Study **1**: 199, *fig. 80*, 206. 1930.

S. nigra Marshall, var. *venulosa* (Andersson) Bebb, n. comb., in Coville (*Botany of the Death Valley Expedition*), Contr. U. S. Nat. Herb. **4**: 199. 1893; as interpreted by Bebb (*Review of the willows of California*), Bot. Gaz. **16**: 102. 1891 (see discussion below).

S. nigra Marshall, var. *wrightii*, as interpreted by Bebb, Bot. Gaz. **16**: 102–103. 1891; as interpreted by Bebb, in Coville, Contr. U. S. Nat. Herb. **4**: 200. 1893; as interpreted by Coulter (*Botany of western Texas*), in part, Contr. U. S. Nat. Herb. **2**: 419. 1894, not Andersson (see discussion below).

S. vallicola (Dudley) Britton, *North American Trees* 184, fig. 1141. 1908.

S. wrightii, as interpreted by Wooton and Standley (*Flora of New Mexico*), Contr. U. S. Nat. Herb. **19**: 160. 1915, not Andersson (see discussion below).

Andersson first published his variety *venulosa* in 1867 (*Monographia salicum*) as a variety of *S. nigra* Marsh., subspecies *longipes* (Shuttleworth), and described the New Mexico plant as having leaves paler to glaucescent beneath. *S. longipes* is the southeastern plant with glaucous leaves now known as *S. caroliniana* Michx. and belongs to section *Bonplandianae*. As its range extends west only to southern Texas, a New Mexico plant with glaucescent leaves would represent either *S. bonplandiana* (section *Bonplandianae*) or *S. wrightii* (*S. amygdaloides* var. *wrightii*) of section *Triandrae*.

When Bebb listed *S. nigra* var. *venulosa*, or var. *wrightii*, as occurring in California, he was dealing with *S. gooddingii* or its variety *variabilis*, because neither *S. bonplandiana* nor *S. wrightii* occurs as far west as California. In 1891, under *S. nigra*, he states that across New Mexico and Arizona it takes on the character of variety *venulosa* and that variety *wrightii* is the same thing. These statements show conclusively that Bebb did not then distinguish between the green-leaved species, *S. nigra* and the then unnamed *S. gooddingii*, and the glaucous-leaved species, *S. bonplandiana* and *S. wrightii*.

Wooton and Standley (*Flora of New Mexico*), in 1915, under their interpretation of *S. wrightii* Andersson, state that the "leaves are light green, of about the same color on both surfaces." Under *S. nigra* they say: "It is very probable that further study of what is here considered *S. nigra* in New Mexico will show that it belongs to *S. wrightii*, which is the common plant of the type." Apparently they were dealing with *S. gooddingii* variety *variabilis* in both cases and did not recognize var. *wrightii* at all because they limit *S. amygdaloides* to the extreme northern part of the State, where it does occur but variety *wrightii* does not.

Separation from S. nigra. In the Southwest, *S. gooddingii* and its variety *variabilis* are the counterparts of the abundantly occurring *S. nigra* and its varieties in the eastern half of the United States. *S. nigra* and its southwestern variety *lindheimeri* Schneider are marked by twigs light brown to dark brown and glabrous or sometimes puberulent; leaves smaller and green to dark green; stipules without glands on the upper (inner) surface, or occasionally a few such glands on var. *lindheimeri*; and capsules shorter in *S. nigra* but sometimes as large (as those of *S. gooddingii* in variety *lindheimeri*, but always glabrous in both.

S. gooddingii and variety *variabilis*, on the other hand, have twigs yellow to yellowish and more of less pubescent-puberulent (especially when young) to glabrous; leaves mostly yellowish green and larger (those on vigorous shoots up to 15–19.5 by 2–3 cm); stipules commonly with abundant fragrant glands on the upper surface; and capsules commonly to 6.5 or 7 mm long and ovaries and capsules always pubescent in *S. gooddingii* but glabrous in variety *variabilis*.

In western Texas (north to south), variety *variabilis* is found on the Canadian River in Hemphill County in the northeastern Panhandle, within the range of both *S. nigra* and variety *lindheimeri*. On the headwaters of the Red River, it reaches Deaf Smith and Donley Counties in the southern Panhandle, Donley County being within the range of variety *lindheimeri*. In the Staked Plains (Llano Estacado), it reaches Hale and Lubbock Counties in the Brazos River drainage, Hale County being in *lindheimeri* territory. Farther south and east it occurs in Tom Green County of the Concho River drainage, occupied also by *S. nigra*. It occupies also most of the mountainous counties in the large triangular area south of New Mexico to as far east as Pecos and Brewster Counties, an area where neither *S. nigra* nor variety *lindheimeri* is found. It has one sporadic occurrence in Starr County, in far southern Texas, where both *S. nigra* and variety *lindheimeri* occur. This occurrence probably resulted from flotation down the Rio Grande.

All known Texas specimens showing the distribution of variety *variabilis* and of *S. nigra* and its variety *lindheimeri* are cited in Dr. Lundell's forth-coming *Flora of Texas.*

The eastern extension of variety *variabilis* from New Mexico into western Texas is interesting ecologically. In northeastern New Mexico it crosses the divide east ofthe Rio Grande and the Pecos River and extends down the headwater streams of the Canadian and Red Rivers, of Mississippi River drainage. In east-central and southeastern New Mexico it crosses the divide east of the Pecos River and extends down the headwaters of the White (Brazos) and Concho (Colorado) Rivers, of the Gulf drainage. It occurs along the Rio Grande and the Pecos River and their tributaries, in southwestern Texas, as far east as Brewster and Pecos Counties, with the one sporadic occurrence noted far down the Rio Grande in Starr County.

On the other hand, *S. nigra* and its variety *lindheimeri* have not been able to cross these divides between the eastward-flowing rivers and southward flowing Rio Grande and Pecos River. In fact, they apparently have not been able to ascend any of these streams to their headwaters. Undoubtedly downstream spread is accomplished with comparative ease and upstream spread with relative difficulty, but why were both species not affected equally when they reached these divides? Did the long-recurring eastward drives of large herds of grass-fed cattle from the Southwest to the frontier Kansas railroads help the eastern spread of western willows? Cattle browse freely on willows, and a piece might be carried far in a steer's mouth. Likewise a stem regurgitated during cud-chewing by animals bedded down for the night near a spring or stream might be dropped and trampled into the mud in the movements of the following morning. Only the few returning cowboys and chuck wagons traveled in the reverse direction.

2. **Salix ligulifolia** (Ball) Ball. (*S. lutea* Nutt., var. *ligulifolia* Ball)

This willow has been so differently treated by so many writers that it seems desirable to review its history, rewrite its description, and cite authenticated specimens to show its recognized wider distribution. It is chiefly in California and Oregon that the known range has been considerably extended. Specimens cited in 1921 are not relisted here.

Salix cordata, as interpreted by Bebb, in Brewer and Watson, *Botany of California* **2**: 85. 1880 (preprinted, with same pagination, as Bebb, *Willows of California*. 1879); as interpreted by Bebb, in Coulter, *Manual of the botany of the Rocky Mountain region:* 335. 1885 (as to distribution in most of the Rocky Mountain area); by Bebb (*Review of the willows of California*), Bot. Gaz. **16**: 104. 1891; and by Ball, in Coulter and Nelson, *New manual of the botany of the Central Rocky Mountains:* 132. 1909 (as to distribution in the Rocky Mountains and westward), not Muhlenberg.

S. cordata Muhl., var. *mackenziana*, as interpreted by Bebb, in Brewer and Watson, *Botany of California:* 286. 1880, and preprint **2**: 86. 1879 (so far as most occurrence in California is concerned); and by Bebb, in Coulter, *Manual of the botany of the Rocky Mountain region:* 335. 1885 (so far as occurrence in most of the Rocky Mountain region is concerned), not Hooker.

S. cordata Muhl., var. *watsoni*, as interpreted by Wooton and Standley (*Flora of New Mexico*), Contr. U. S. Nat. Herb. **10**: 159. 1915 (so far as southern distribution is concerned), not Bebb.

S. ligulifolia Ball, in litt. —?, Schneider, Journ. Arnold Arb. **2**: 188(–189). April 1921 (nomen nudum).

S. ligulifolia Ball (*S. lutea* var. *ligulifolia* Ball), n. comb., apud Smith (*Willows of Colorado*), Amer. Midl. Nat. **27**: 236(–237), January 1942; Kearney and Peebles (as synonym of the variety, see below); Thompson, Albert E., *Salix ligulifolia* Ball, *The strap-leaved willow and its relatives in the central Sierra Nevada:* 6 pp. (typed, not published). 1942; rev. ed. 1943.

S. lutea Nutt., var. *ligulifolia*, n. var., Ball, Bot. Gaz. **71**: 428(–430). June 1921; Ball, in Abrams, *Illustrated flora of the Pacific States* **1**: 494. 1923; Tidestrom (*Flora of Utah and Nevada*), Contr. U. S. Nat. Herb. **25**: 136. 1925; Kearney and Peebles (*Flowering plants and ferns of Arizona*), U. S. Dept. Agr. Misc. Publ. 423: 220. May 1942 (*S. liqutifolia* Ball as synonym).

Frutex; ramulis veterioribus fuscis ferrugineis aut nigrescentibus, juvenioribus flavescentibus aut fuscentibus saepe pubescentibus; foliis ligulifformibus anguste lanceolatis aut anguste oblongo-lanceolatis subtus glaucis; capsulis 4–5.5 mm longis glabris.

Shrub with clustered stems, commonly 1–3 meters tall, rarely 4–5 meters (Plumas County) general color effect dark green; bark dark gray; branchlets varying with age, the new growth yellowish and generally puberulent, summer-grown twigs yellowish to brown and often pubescent to densely so, 1-year and 2-year twigs brown or reddish brown to blackish, often shining, mostly glabrous or the 1-year retaining (or renewing) previous pubescence; buds ovate-

lanceolate, 5–10 mm long, acute or obtusish, colored and clothed as the twigs, often drying black; stipules semiovate and acute to semilunate and obtuse, 4–10 mm long, or to 15–18 mm on vigorous shoots, entire to serrulate, mostly glabrous, glaucous beneath; petioles stoutish, 5–10 mm long, yellowish to brown, pubescent to glabrous; leaves midsized, ligulate, or lanceolate, or oblong-lanceolate (narrowly oblanceolate while unfolding), 5–10 cm long by 1–2 cm wide, or 11–13.5 by 2.5–3 cm on vigorous shoots, acute or very short-acuminate at apex, broadened, rounded, truncate, or cordate at base, subentire or more or less serrulate or glandular-serrulate, the largest sometimes toothed near base, reticulate veiny on both sides, especially beneath, dark green above, glaucous to white-glaucous beneath, glabrous after unfolding or the whitish midrib puberulent above on the basal portion.

Aments coetaneous or somewhat precocious, the staminate slender, 2–3 cm long, sessile and naked or with 1–2 small bracts at base; pistillate 2–4 or 5 cm long, to 1.4 cm wide in fruit, subsessile or on leafy-bracted peduncles 5–10 mm long; scales elliptic-oblong, obtusish, brownish, drying black, densely white-tomentose or the apex becoming glabrate externally; stamens 2, filaments glabrous, free; capsules small, lanceolate or ovate-lanceolate, 4–5.5 mm long, glabrous; pedicels mostly 1.5–2.5 mm long, rarely 3.5 mm, glabrous; styles 0.3–0.5 or 0.7 mm long, mostly entire; stigmas short, entire, notched, or bifid; gland short. The flowering period covers late April and May, with fruiting continued thereafter.

Salix ligulifolia is a clumpy shrub of mountain streams and meadows, at altitudes ranging from 3,000 to 9,000 or rarely 9,500 feet (900–2,700 or 2,850 meters) but occurring most commonly at altitudes of 4,000 to 7,000 feet (1,200–2,100 meters). It often is associated with *S. lasiandra* Benth. and *S. lemmoni* Bebb in the Sierra Nevada. It ranges from the Black Hills of South Dakota (Custer County), and the Laramie and Medicine Bow Mountains of southeastern Wyoming, southward across Colorado and New Mexico, westward in Arizona, and northward in the Sierras of California from Tulare County to Plumas and Tehama Counties. There is sparse or sporadic occurrence in southern Utah and Nevada, and in Klamath, Jackson, and Josephine Counties of extreme southern Oregon also.

It is the southwestern representative of the section *Cordatae*, as *S. lutea* Nutt. is the western, *S. mackenziana* (Hooker) Barratt the northwestern, and *S. rigida* Muhl. (*S. cordata* Muhl., not Michx.) the eastern. It parallels *S. rigida* most closely in the variability of hairiness on the vegetal organs. What one finds depends much on the stage of their development when observed or collected. The ranges of the dark-twigged *S. ligulifolia* and *S. mackenziana* scarcely overlap at all, but yellow-twigged *S. lutea* and its varieties occur throughout much of the ranges of both the others.

The distribution was well indicated by the specimens cited in 1921, except for California and southern Oregon. California was credited then with a single collection and Oregon with none. Below are cited those recognized by the writer since 1921.

WYOMING. Laramie County: Sybille Creek, *Elias Nelson 672*, in 1901 (CRB). Albany County, Woods Creek, *L. N. Goodding 1432*, in 1903: (CRB); Sand Creek, *Aven Nelson 6965*, in 1900 (CRB); Laramie River, near Laramie, alt. 7,000 feet, *Louis C. Williams 2812*, in 1935 (CRB, and in USN as no. 2212).

COLORADO (alphabetical). Alamosa County: Alamosa, *Hazel M. Schmoll 1032, 1033*, in 1924 (CRB). Archuleta County: San Juan National Forest, *S. Duval Anderson A 49½*, in 1925 (FS 50272½). Boulder County: Ward, alt. 9,150 feet, *Schmoll 601*, in 1922 (CRB). Conejos County: Conejos River, *Goodding Sal.-50A*, in 1938 (CRB). Costilla County: 10 miles west of LaVeta Pass, *Goodding & Leston Goodding Sal. 20–39*, in 1939 (CRB). El Paso County: near Colorado Springs, *E. C. Schneider J-1, J-4, NC-4, NC-6 PS-3, WC-3, WC-5*, all in 1910 (all CRB); Beaver Creek, 3 miles west of Monument, *E. R. Warren 3, 4*, on June 9, 1926 (CRB, USN). El Paso-Teller Counties: Pikes Peak Forest Reserve, S. J. Flintham, on September 2, —— (USN, as *S. lutea* var. *watsoni*); Pikes Peak region, alt. 6,750–9,500 feet, *I. M. Johnston 2779, 2780, 2781* (USN), *2782* (USN), *2783, 2784, 2785, 2786*, in 1920 (all CRB). Gunnison County: Anthracite Creek, alt. 8,800 feet, *Warren 21*, in 1927 (CRB); Fitzpatrick Mesa, 2 miles west of Blue Creek, alt. 8,500 feet, *R. C. Rollins 1991*, in 1937 (CRB). Larimer County: La Porte, *Ernest C. Smith 660, 818*, in 1935 *721, 723*, in 1936 (all CRB) Rio Grande County: Vicinity of Monte Vista, *Schmoll 1040, 1057*, in 1924 (CRB). Teller County: East of Divide, *J. H.*

Christ 213, in 1935 (CRB). Teller–El Paso Counties: See El Paso–Teller Counties, above. Weld (?) County: Chimney Rock, on Sand Creek, 50 miles north-northeast of Fort Collins, *Smith 1710*, in 1945 (CRB).

NEW MEXICO. Catron County: Beaverhead Ranger Station, *Goodding & Goodding Sal.-5-39*, in 1939 (CRB). Colfax County: Cimarron Creek Soden and Baldy Meadow, *Goodding & Goodding Sal.-6-39*, in 1939 (CRB). Rio Arriba County: 81 miles north of Santa Fe, on road to Chama, *Goodding Sal.-54*, in 1938 (CRB); west slope of Sierra Nacimiento, *Goodding Sal.-83*, in 1938 (CRB, as *S. mackenziana* var. *macrogemma* Ball). Specimens from Grant, Lincoln, and Union Counties cited in 1921.

UTAH. Kane County cited in 1921.

NEVADA. Washoe County: Reno, *Ivar Tidestrom 10623*, in 1919 (CRB).

ARIZONA. County unknown: Beaver Creek, B. E. Fernow, in August 1896 (USN). Numerous specimens from east-central portion cited in 1921. Coconino County: Upper Oak Creek near Flagstaff, *H. J. Fulton 7166*, in 1930 (USN).

OREGON. Klamath County; Johnson Prairie, *Elmer I. Applegate 2472*, in 1898 (USN); south end of Lake of the Woods, *F. V. Coville 1205*, in 1902 (USN); 5 miles northeast of Fort Klamath, *Morton E. Peck 19732*, in 1937 (CRB); near creamery, Klamath Agency, Wood River, *F. A. Walpole 2217*, in 1902 (USN). Jackson County: Jackson Creek, ¾ mile west of Jacksonville, *L. R. Abrams & J. T. Benson 10261*, in 1924 (CRB, distr. as *S. lasiandra*); determined later by Ball as *S. mackenziana*); Medford, *H. B. Humphrey 2054*, in 1916 (CRB, as *S. mackenziana*); Gold Hill, *Walpole 149*, in 1899 (USN, too juvenile for complete certainty). Josephine County: Gravelly flood-plain, east fork of Illinois River, near Highway 199, *Carleton R. Ball & Harold E. Parks 01278*, in 1932 (CRB).

CALIFORNIA (north to south). Tehama County: South fork of Battle Creek, 1.7 km northeast of Mineral, *Ball, Bracelin & Kautz 379*, in 1931 (CRB, USN). Plumas County: 1 mile southeast of Fowler Peak, *D. Axelrod 6791*, in 1934 (CRB); North Fork of Feather River, at Chester, *Ball, Bracelin, & Kautz 393, 394, 397, 398*, in 1931 (CRB, several sheets of each; USN). Butte County, Jonesville, *E. B. Copeland 621* and 3 unnumbered, on June 10, 18, and 20, 1931 (CRB); Copeland, in May 1938 (CRB). Placer County, French Meadows, American River, Tahoe National Forest, *L. S. Smith 3*, in 1931 (CRB). El Dorado-Placer Counties: Tahoe-to-Placerville Road, with *S. lemmoni*, *Emily Smith 14*, in 1933 (CRB). Tuolumne County (Yosemite National Park): Carl Inn, Big Oak Flat and Tioga Roads, *Ball, Bracelin, & Emily Smith 552*, in 1931 (CRB); same, *Smith 3a*, in 1933, (CRB); south fork of Tuolumne River, in west edge of park, *Albert E. Thompson 1195, 1197, 1199*, in 1941 (CRB). Mariposa County (mostly Yosemite National Park): Illilouette Canyon, alt. 1,940–1,970 meters, *E. B. Babcock 1058*, in 1912 (USN, as *S. cordata mackenziana*); Crane Flat on Big Oak Flat Road, *Ball, Bracelin, & Kautz 509*, in 1931 (CRB, USN); Big Creek, tributary of south fork of Merced River, just outside park, *Thompson 1105, 1106, 1109*, in 1941 (CRB); Wawona, *Thompson 1182*, in 1941 (CRB). Madera County: The Falls, Bass Lake, *Thompson 253, 255, 256, 257*, in 1939 (CRB); same, *Thompson 1008*, in 1941 (CRB); area of south fork of Willow Creek, *Thompson 1043, 1044, 1045, 1046, 1048, 1049, 1051, 1052, 1053, 1075, 1076, 1084, 1092, 1097*, in 1941 (all CRB); area of Big Creek, near Fresno Dome, and Beasore Meadow, etc., *Thompson 1099, 1122, 1123, 1205, 1206, 1214, 1217, 1219*, in 1941 (CRB). Fresno County: near shore of Hume Lake, *Thompson 255*, in 1939 (CRB); Indian Basin, Kings River Canyon Highway, *Thompson 259, 262, 264*, in 1939 (CRB); area of Sequoia Lake Dam, *Thompson 391, 396*, in 1940 (CRB); same, *Thompson 1029*, in 1941 (CRB); Huntington Lake, alt. 7,000 feet, *Thompson 929, 938*, in 1939, and *1172*, in 1941 (CRB). Tulare County: South end of Crescent Meadows, alt. 7,240 feet, *Mrs. H. P. Bracelin 802, 803*, in 1933 (CRB); Heather Lake Trail, alt. 7,500–7,600 feet, *Bracelin 807b, 808*, in 1933 (CRB).

3. **Salix lasiolepis** Bentham, var. **bracelinae**, n. var.

Salix irrorata, in part, as interpreted by Ball, in Coulter and Nelson, *New manual of the botany of the Central Rocky Mountains:* 132. 1909 (by twigs "or downy-puberulent" and by the Texas, and probably some of the New Mexico, distribution), not Andersson.

Salix lasiolepis Bentham, *Plantae Hartwegianae:* 355. 1857 (in part); Andersson, Öfv. Kon. Vet.-Akad. Förh. **15**: 118. 1858 (in part); printed simultaneously in Proc. Amer. Acad. Arts and Sci. **4**: 58. 1858 (reprinted as *Salices Boreali-Americanae:* 12); Andersson, in DC., Prodr. **16**(2): 264. 1868 (in part); Ball, in Abrams, *Illustrated flora of the Pacific States* **1**: 496. 1923 (in part). Goodding (*Willows in Region VIII*), U. S. Dept.

Agr. Soil Cons. Serv. Reg. Bull. **65**: 8, *illus.* 1940 (mimeogr.); Kearney and Peebles (*Flowering plants and ferns of Arizona*), U. S. Dept. Agr. Misc. Publ. **423**: 219. 1942; Schneider, Bot. Gaz. **65**: 31. 1918 (distribution in Mexico); Schneider, Journ. Arnold Arb. **2**: 187–188. 1921 (in part); Wooton and Standley (*Flora of New Mexico*), Contr. U. S. Nat. Herb. **19**: 159. 1915.

A forma typica species differt foliis linearibus, lineari-ellipticis, lineari-lanceolatis, aut lineari-oblanceolatis. Shrub 2–5 or 6 meters, or small tree 5–8 or 9 meters (17–30 feet) tall, with clustered stems and grayish bark; twigs mostly stoutish, the seasonal yellowish and pubescent to puberulent, the 1-year yellowish to brownish and often pubescent or puberulent before the epidermis peels off in the spring and sometimes becoming puberulent thereafter, the older chestnut-brown to dark-brown and glabrate to glabrous; buds stout, 2–6 mm long, or 6–10 mm long and 2–4 mm wide on vigorous shoots, colored and clothed much as the supporting twigs; stipules 2–4 or 8 mm long, obliquely lanceolate, ovate, or sublunate, sometimes serrulate, glaucous beneath.

Leaf-petioles stoutish, 5–10 or 15 mm long, yellowish and pubescent while young, becoming brownish and glabrate-glabrous with age; blades very narrow, linear-elliptical, linear-lanceolate, linear-oblanceolate, or sometimes narrowly oblong, 6–10 cm long and 0.8–1.5 cm wide, or to 11–15 cm by 1.5–2 cm on vigorous shoots, narrowed at base, acute or short-acuminate at apex, subentire to irregularly undulate-denticulate or undulate-serrulate and somewhat revolute at margins, gray-pubescent while unfolding, usually becoming glabrate to glabrous with age, dark green and somewhat shining above, densely glaucous and reticulate beneath, the yellowish midrib prominent on both sides and often minutely puberulent above in maturity.

Aments precocious, often appearing in December-January in the axils of the old leaves, especially southward, subsessile at first, 3–7 cm long; the staminate 1.2 cm wide, stamens 2, filaments glabrous, usually united for ½ or more of their length; pistillate 1–1.4 cm wide, the peduncle in fruit 2–5 or 8 mm long and bearing 2–4 tiny bract-like leaves; scales in both sexes persistent, obovate, very obtuse, 1–1.2 mm long, dark brown or blackish, densely clothed with long straight or tangled hairs; capsules lanceolate, 3.5–4.5 mm long, greenish, glabrous; pedicels 0.5–1 or 1.5 mm long, glabrous; styles 0.4–0.8 mm. long, entire of more or less bifid; stigmas shorter, usually notched.

This southern variety of *S. lasiolepis* is named for Mrs. H. P. Bracelin, of Berkeley, Calif., in recognition of her extensive and discriminating collecting, and her careful and informative labeling, of California willows over a period of years. The material thus made available has added greatly to our knowledge of the characteristics, habitats, and distribution of the numerous species and varieties in that State.

The narrow-leaved arroyo willow is a shrub or small tree, occurring mostly along mountain streams at middle altitudes from southern California and northern Baja California eastward in southern parts of Nevada and Utah, most of Arizona and New Mexico, southwestern Texas, and northern Sonora and Chihuahua in Mexico. In California, it ranges from 2,500 or 3,000 feet to 6,000 and sometimes 7,200 feet in altitude. In the other States it occurs mostly from 5,000 to 7,500 or 8,000 feet. It flowers in January and February southward and at lower altitudes and in March and April northward and at higher altitudes.

The center of distribution for *S. lasiolepis* is in the southern two-thirds of California, where the species and all its four varieties are found. Their total distribution area is shaped like a boot facing east, the foot to the south and the top to the north. The heel (Baja California) and sole (Sonora, Chihuahua) are in Mexico. The foot extends from the southern half of California and adjacent Nevada and Southern Utah across Arizona and New Mexico, with the toe in southwestern Texas. The top extends northwards from northern California and Nevada into Washington and Idaho.

There is progressive widening of the leaves from south to north in this total area. Variety *bracelinae*, with rather linear leaves, occupies the foot of the boot. *S. lasiolepis*, with oblanceolate leaves, ranges from the heel in Baja California northward to Washington and Idaho. Variety *bakeri*, of the Bay Area, does not differ in leaf shape. Variety *bigelovii*, with obovate leaves, is found mostly near the coast, and variety *sandbergii*, with elliptic-oval or obovate-oval leaves, is found in northern California and Idaho. A fifth variety, *fallax* Bebb, if recognized, has elliptical leaves and is found in the Sierra Nevada. The species not only has broader leaves than variety *bracelinae* but the twigs usually

darken more rapidly and more completely. In southern California and adjacent Nevada, the species is about as common and widely distributed as is variety *bracelinae* and also occurs sparingly in northern Arizona.

Because the center of distribution for the species and its varieties is near the coast in central California, distribution is indicated here from north and west to south and east. Authenticated specimens of variety *bracelinae* are cited, for States and Counties, by collector, number, and year. Where there is no collection number, fuller data are given. Citation of Mexican specimens follows that of United States specimens. Containing herbariums are indicated as follows: Carleton R. Ball (CRB); U. S. Forest Service (FS); N. Y. State Museum (NYSM); Omer E. Sperry (OES); Pomona College (PC); Southern Methodist University (SMU); Texas A. and M. College (TAC); Texas State University (TSU); and U. S. National Herbarium (USN).

CALIFORNIA, CENTRAL. Sonoma County: Bodega Bay, *W. A. Setchell 19*, on 1931 (CRB); Russian River between Monte Rio and Duncan's Mills, *Setchell 22*, in 1931 (CRB). Yuba County: Horse Hop Ranch, Wheatland, *Carleton R. Ball 1718*, in 1911 (CRB, USN). Contra Costa County: Antioch, *Alice Eastwood 3726*, *3727*, *3728*, *3729*, in February 1914 (USN, *3728* stam. type; *3729* pist. type; both with persistent leaves of 1913). Alpine County; Markleeville, Diamond Ranch, alt. 5,500 feet, *H. Lee 107*, in 1934 (CRB). Madera County: Northfork, E. G. Dudley, November 1911 (CRB). Fresno County: Millwood, *J. D. Culbertson 4665*, in 1904 (USN). Monterey County: Between Jelon and Memorial Park, *Milo S. Baker 7932*, in 1934 (CRB). Tulare County: Near Visalia, *F. V. Coville & Frederick Funston 268*, in 1891 (USN, vigorous shoot with large leaves). Inyo County (all from Panamint Mountains): *Coville & Funston 493*, *597*, *625*, in 1891 (USN); *Coville & M. French Gilman 221*, *222*, alt. 7,300 feet, in 1931 (USN); *Gilman 2134*, *2138*, *2156*, *2232*, in 1936 (USN); Willow Springs, 14 miles east of Independence, *Mark Kerr 71*, in 1932 (CRB); some others are too juvenile for certain determination.

CALIFORNIA, SOUTHERN. Kern County: Edge of desert, 1 mile east of Walker Pass Summit, alt. 5,250 feet, *Mrs. H. P. Bracelin*, *Carl Skottsberg*, & *J. T. Howell 2870*, *2871*, in 1948 (CRB, some old leaves persisting); Tejon Mountains, *F. R. Fosberg 7054* (CRB, USN), *7055*, (CRB), *7056* (CRB, 5 sheets; USN), all in 1931; Johnson Canyon, Walker Basin, *Fordyce Grinnell 61*, in 1905 (USN); Mount Pinos, San Emigdio Poturos, *H. M. Hall 6390*, in 1905 (CRB). Ventura County: Topa Topa Mountains, *L. R. Abrams & E. A. McGregor 105*, in 1908 (USN); Mount Pinos region, *W. R. Dudley & F. H. Lamb 4616*, in 1896 (USN); same, *C. Epling & L. C. Wheeler 1831*, in 1933 (CRB); same, Ralph Hoffmann, on June 5, 1930 (CRB): Mount Pinos, *Carl W. Sharsmith 1*, on October 25, 1931 (CRB). Los Angeles County: Inglewood, *Abrams 3103*, in 1902 (USN); *Bracelin & Fosberg 572*, in 1931 (CRB); Sierra Santa Monica, *W. H. Brewer 86*, *87*, *88*, on December 23, 1860 (USN, new aments, old leaves persisting); same, *Fosberg 5852*, in 1931 (CRB); same, *Fosberg 7172* (USN), *7173*, *7176* (USN), *7177* (USN), *7178* (USN), *7179*, all January 26, 1932 (all CRB); same, *Fosberg 7410*, *7412*, *7414*, *7415*, all March 3, 1932 (CRB); same, Walter M. Moode, on October 6, 1912 (CRB); San Gabriel Mountains, *George L. Moxley 1038*, in 1921 (USN); same, Ojai, S. F. Peckham, on February 4, 1866 (USN); same, *F. W. Peirson 4281*, in 1919, *9767* in 1932 (both CRB); same, *Sharsmith 3*, *4*, in 1931 (CRB); San Gabriel Canyon, *Sharsmith 6*, *7* (USN), *7a*, *9* (USN) *10*, all in 1932 (all CRB, with some persisting leaves of 1931); same, *Wheeler 1467*, *1472*, in 1933 (CRB). Orange County: Temiscal Range, *Brewer 154*, in January 1861 (USN). San Diego County: Pine Valley Creek bridge, 9.5 km east of Descanso, alt. 1,020 meters, *Bracelin 618*, *619*, in 1932 (CRB, USN); San Diego, J. G. Cooper, in 1860–67 (USN); same, *Carl V. Meyer 828*, on December 26, 1931 (CRB, old leaves persisting); Camp Kearney, *Harold E. Parks 0332a*, in 1929 (USN); same, *Parks & Susan T. Parks*, *01091a*, *b*; *01092a*, *b* (b in USN); *01093a*, *b*, all January 17, 1932 (all CRB, all stam. spec. (a), and one pist. spec. (b), with old leaves persisting); some other collections by Bracelin and by Meyer are too juvenile for certain determination as variety.

CALIFORNIA, SOUTHEASTERN. San Bernardino County (practically all from San Bernardino Mountains): Cajon Pass, *Coville & Funston 129*, in 1891 (USN); south fork of Santa Ana River, alt. 6,200 feet, *J. & H. W. Grinnell 356*, in 1906 (USN); San Bernardino, *J. B. Leiberg 3242*, in 1898 (USN); same, C. D. Mell, on February 10, 1904 (CRB); same, *P. A. Munz 12664*, *12709*, in 1932 (CRB); same, *S. B. Parish 3004*, in 1894, *4625*, in 1901 (both USN); same, *Peirson 9972*,

in 1932, at 6,900 feet alt. (CRB); same, *George R. Vasey 271*, *273*, in January 1881 (USN); same, Vasey, in February 1881 (USN, 1 sheet (pist.) with persisting old leaves; 3 others, including *274*, represent the species). San Bernardino or Riverside Counties (mostly in San Bernardino Mountains): *Munz & Johnston 5241*, in 1922 (CRB); *Munz 5732*, in 1922 (CRB); *Munz 12905*, in 1932, at 7,200 feet alt. (CRB); *S. B. & W. F. Parish 675*, in 1881 (NYSM, USN, new aments and old leaves on December 20). Riverside County: Corona, Richard L.Cosby, on January 11, 1945 (CRB, "good pollen and nectar plant for bees"); Strawberry Valley, W. L. Jepson and Hall, on May 17–June 1, 1901 (NYSM); San Jacinto Mountains, *Munz & Johnston 5518*, in 1922 (CRB); same, *Setchell & Duran 7*, in 1935 (CRB).

Nevada. Nye County: 20 miles northeast of Warm Springs, *K. H. McKnight & Calvin McMillan 38*, in 1942 (CRB). Lander County: Up Skull Creek near Grass Valley Ranch, *F. S. Goodner & W. H. Henning 446*, in 1937 (CRB); Le Madre Mountains, *Ivar Tidestrom 10964*, in 1919 (USN). Clark County: Excelsior Canyon, Charleston Mountains, *I. W. Clokey 8752*, in 1941 (CRB); Toyabe Range, *Clokey 7885*, in 1919 (USN, probably the variety, but other collections there are the species).

Utah. Washington County: 3 miles east of Pine Valley, alt. 7,000 feet, *Frank W. Gould 1781*, in 1942 (CRB). Iron County: Parawan, alt. 1,800–2,000 meters, *W. W. Eggleston 14903*, in 1918 (USN). All other Utah specimens seen are of the species.

Arizona. Coconino County (all from Flagstaff): *Chester F. Deaver 44*, in 1941 (CRB); Mount Eden, alt. 7,500 feet, *E. A. Goldman 2059*, in 1913 (USN) Yavapai County (all Prescott): Elmer D. Ball, in August–September 1932 (CRB); E. W. Gifford, on June 12, 1932 (CRB); *Peebles, Harrison, & Kearney 2618*, in 1926 (USN). Apache and Navajo Counties (southern parts, and perhaps adjacent parts of Coconino and Gila Counties also, mostly in the White Mountains Indian Reservation and Black Mesa Forest Reserve): *Coville 1008*, *1018*, *1056*, *1064*, *1077*, *1085*, *1094*, in 1900 (all USN); *Coville 1912* (probably Gila County), *2023*, in 1904 (USN). Gila County: *Bassett Maguire 10054*, in 1930 (CRB); the species is represented by Walter Hough 92, from Gila County in 1901 (USN). Graham County: *E. G. H. 118*, on May 20, 1914 (CRB, as *S. irrorata*); *H. H. Rusby 372*, in February 1881 (USN, 2 sheets). Pima County (Santa Catalina Mountains): *David Griffiths 7037*, in 1904 (CRB); *J. Arthur Harris C16437*, in 1916 (USN); alt. 7,500 feet, *R. H. Peebles 4072*, in 1927 (USN); same alt., *Peebles & H. F. Loomis 7105*, in 1930 (USN); alt. 7,900 feet, *R. D. Roseberry 79*, in 1937 (CRB); J. J. Thornber, on February 15, 1904 (USN): *Tidestrom 12560*, in 1927 (CRB); *George R. Vasey 8* (number in pencil), in March 1881 (USN). Pima or Santa Cruz County (Santa Rita Forest Reserve): *Griffiths 4198*, in 1903 (CRB, USN). Cochise County (Chiricahua Mountains): Dan Axelrod, on May 7, 1941 (CRB); *J. C. Blumer 2281*, *2282*, *2283*, *2303*, in 1906 (CRB); *W. W. Eggleston 11011*, in 1914 (USN); *J. W. Toumey 183*, in 1894 (CRB); Toumey, in March and July 1894 (USN); Toumey, on May 1, 1897 (USN). Cochise County (Huachuca Mountains): *L. N. Goodding 372*, *914*, *1040*, in 1949 (CRB); *Kearney & Peebles 13846*, in 1937 (USN); *E. A. Mearns 2176*, *2614*, in 1893 (USN); *T. E. Wilcox 81*, *84*, in 1894 (USN). County unknown: Beaver Creek, B. E. Fernow, in August 1896 (USN).

New Mexico. Catron County: Beaverhead Ranger Station, *Goodding 30*, *31*, on May 20, 1938 (CRB, twigs somewhat pruinose): Reserve, *Goodding A 9633*, in 1939 (CRB). Colfax County: *Goodding A 9645*, in 1939 (CRB). Dona Ana County (all Organ Mountains, by E. O. Wooton): Filmore Canyon, alt. 5,500 feet, on February 10, March 12 (3 sheets), and April 15 (2 sheets), in 1899 (USN); same, alt. 7,000 feet, on April 15, 1899 (USN); same, alt. 7,000 feet, on April 18, 1903 (USN, 2 sheets); Organ Peak, alt. 8,000 feet, on April 18, 1903 (USN).

Texas (several specimens with twigs faintly pruinose). Brewster County: Infrequent at Buena Vista, *B. H. Warnock 123*, in 1937 (USN). Culberson County (Guadalupe Mountains): *Paul C. Standley 40485*, in 1924 (USN); M. S. Young, on August 29, 1916 (TSU). Jeff Davis County (Davis Mountains): *Vernon Bailey 407*, in 1901 (USN); *D. C. Correll 13548*, *14064*, in 1946 (SMU); *V. L. Cory 53086* (USN), *53106*, *53158*, in 1946 (all SMU); *L. C. Hinckley 1095*, in 1935 (CRB, TSU); *C. L. & Amelia A. Lundell 14251*, in 1945 (CRB, SMU); *C. H. Muller 8184*, in 1945 (SMU); *E. J. Palmer 30799*, *32008*, *32157*, in 1926 (CRB, TSU, USN); *Palmer 33431*, *34479*, in 1928 (USN); *H. B. Parks & V. L. Cory 9098*, in 1934 (CRB, TAC); *Parks & Cory 18520*, *18521*,

in 1936 (TAC); *Omer E. Sperry T 2*, on May 3, 1936 (OES, USN). Presidio County: Sierra Tierra Vieja, *Hinckley 2726, 2727*, in 1943 (CRB); Chinata Mountains, *Hinckley & Warnock 46900*, in 1946 (CRB). County unknown: Valery Havard, in October 1883 (USN).

MEXICO. Baja California: Hamilton Ranch, Marcus E. Jones, on April 15, 1925 (USN); San Vicente and vicinity, Jones, on December 16, 1927 (PC, as *S. laevigata*); Nachoguero Valley, *L. Schoenfeldt 3436*, in 1894 (USN); 2 miles south of Santa Tomás, alt. 585 feet, *Ira L. Wiggins 4271*, in 1930 (USN); La Encinal, on west side of Sierra San Pedro Mártir, alt. 6,000 feet, *Wiggins 9798*, in 1941 (USN). Sonora (region of Río de Bavispe): Jarilla, Cañon de Bavispe, *Stephen S. White 3312*, in 1940 (CRB); Las Tierritas de El Temblor, Sierra de El Tigre, *White 3397*, in 1940 (CRB); Rancho del Robles, northeast of El Tigre, alt. 6,000 feet, *White 4276*, in 1941 (CRB). Chihuahua: Sierra Madre Mountains, alt. 7,000 feet, Jones, on September 19, 1903 (PC); Mojarichic, *Irving Knobloch 5849*, in 1939 ( ); same, *Knobloch 7052*, in 1940 ( ); Majalca, *Harde Le Seuer 593*, in 1936 (SMU); valley near Chihuahua, *C. G. Pringle 709*, in 1886 (USN, 3 sheets). Coahuila: San Lorenzo Canyon, mountains near Saltillo, alt. 7,000 feet, *Pringle 10210*, in 1906 (USN).

ZOOLOGY.—*The feather-stars, sea-urchins, and sea-stars of the United States Navy Antarctic Expedition 1947–48.* AUSTIN H. CLARK, U. S. National Museum.[1]

While accompanying the United States Navy Antarctic Expedition 1947–48 Comdr. David C. Nutt, USNR, assembled a large and representative collection of echinoderms. Most of the specimens are from Marguerite Bay and the immediate vicinity of the Palmer Peninsula, but a few are from as far east as Knox Land.

Although there are no new species of Crinoidea, Echinoidea, or Asteroidea, the additional records are of much interest.

CRINOIDEA

ANTEDONIDAE

HELIOMETRINAE

Promachocrinus kerguelensis P. H. Carpenter

Promachocrinus kerguelensis P. H. Carpenter, Proc. Roy. Soc. **28**: 385. 1879; *Challenger* Reports, Zoology, **26** (pt. 60): 350, pl. 1, figs. 1, *a–d*, pl. 70. 1888.

Localities.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (11 specimens, U.S.N.M. no. E.7975).

Marguerite Bay; 40 fathoms; water temperature 30° F.; February 22, 1948 (7 specimens, U.S.N.M. nos. E.7976, E.7978).

Off Knox coast (lat 66° 31′ S., long. 110° 26′ E.); 100 fathoms; January 19, 1948 (1 specimen, U.S.N.M. no. E.7974).

Notes.—The specimens from Marguerite Bay in 35 fathoms all have 10 rays and 20 arms from 35 to 150 mm long; most of them are small. The specimens from Marguerite Bay in 40 fathoms all have 10 rays and 20 arms, in the largest 160 mm in length; all are large. The specimen from the Knox coast has 6 rays and 12 arms 150 mm long; the cirri are 50 mm long.

Florometra mawsoni A. H. Clark

Florometra mawsoni A. H. Clark, Australasian Antarctic Exped. 1911–14, Sci. Rep., ser. C, Zool. and Bot., **8** (4): 10. 1937.—John, *Discovery* Reports **18**: 144, pl. 3, fig. 2. 1938.

Locality.—Lat. 65° 25′ S., long. 101° 13′ E.; 100 fathoms; water temperature 30° F.; January 14, 1948 (1 specimen, U.S.N.M. no. E.7973).

ECHINOIDEA

ECHINIDAE

Sterechinus antarcticus Koehler

Sterechinus antarcticus Koehler, Resultats du voyage du S. Y. *Belgica* en 1897–1898–1899; Rapports scientifiques, Zoologie: Échinides et ophiures: 8, pl. 2, figs. 9, 10, pl. 3, fig. 18, pl. 8, figs. 55, 56. 1901.

Localities.—Off Cape Royds, Ross Island; 58 fathoms; January 29, 1948 (3 specimens, U.S.N.M. no. E.7653).

Marguerite Bay; 115 fathoms; water temperature 30.2° F.; February 18, 1948 (2 very small specimens, U.S.N.M. no. E.7652).

Marguerite Bay; 35–105 fathoms; water

[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 10, 1950.

temperature 30.2° F.; February 19, 1948 (16 specimens, U.S.N.M. nos. E.7649, E.7650).

Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (3 small specimens, U.S.N.M. no. E.7708).

Island in Marguerite Bay; tide pools; February 21, 1948 (4 specimens, U.S.N.M. no. E.7648).

Marguerite Bay; 40 fathoms; water temperature 30° F.; February 22, 1948 (59 specimens, U.S.N.M. nos. E.7651, E.7655, E.7656).

Notes.—Two of the specimens from tide pools on an island in Marguerite Bay measure, diameter 38 mm, height 23 mm, and diameter 38 mm, height 22 mm.

The specimens from Marguerite Bay in 40 fathoms are up to 30 mm in diameter.

ASTEROIDEA

ASTROPECTINIDAE

Leptychaster magnificus (Koehler)

Priamaster magnificus Koehler, Deuxième Expédition Antarctique Française (1908–1910): Échinodermes (Astéries, Ophiures et Échinides): 92, pl. 8, figs. 1, 3, 8. 1912.

Locality.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (2 specimens, U.S.N.M. nos. E.7638, E.7642).

Note.—One of the specimens has R = 150 mm; in the other R = 65 mm, r = 25 mm.

Psilaster charcoti (Koehler)

Ripaster charcoti Koehler, Expédition Antarctique Française (1903–1905), Échinodermes: 4, pl. 3, figs. 20, 21, 31, 32. 1908.

Localities.—Peter Island; 30 fathoms; water temperature 29.6° F.; February 15, 1948 (4 specimens, U.S.N.M. nos. E.7640, E.7641, E.7677).

Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (2 specimens, U.S.N.M. no. E.7639).

Notes.—Three of the specimens from Peter Island have the following measurements: R = 90 mm, r = 27 mm; R = 85 mm, r = 26 mm; R = 55 mm, r = 14 mm. In the largest the spines on the marginals are strongly developed.

In one of the specimens from Marguerite Bay R = 110 mm, r = 30 mm; the spines on the marginals are strongly developed. In the other R = 100 mm, r = 30 mm; spines are present on the infero-marginals only at the base of the arms; after the basal half of the arms the spines on the superomarginals are represented by a few small ones on the aboral ends of the plates.

ODONTASTERIDAE

Odontaster meridionalis (E. A. Smith)

Astrogonium meridionale E. A. Smith, Ann. Mag. Nat. Hist. (ser. 4) **17**: 109. 1876.

Locality.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (1 specimen, U.S.N.M. no. E.7645).

Note.—In this specimen R = 18 mm, r = 10 mm.

Odontaster validus Koehler

Odontaster validus Koehler, Expédition Antarctique Française (1903–1905), Échinodermes: 6, pl. 3, figs. 22–26. 1906.

Localities.—Off Cape Royds, Ross Island; 58 fathoms; January 29, 1948 (32 specimens, U.S.N.M. nos. E.7643, E.7686).

Near Cape Royds; caught along the beach; January 29, 1948 (2 specimens, U.S.N.M, no. E.7644).

Marguerite Bay; 115 fathoms; water temperature 30.2° F.; February 18, 1948 (1 specimen, U.S.N.M. no. E.7654).

Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1943 (1 specimen U.S.N.M. no. E.7641).

Marguerite Bay; 40 fathoms; water temperature 30° F.; February 22, 1948 (7 specimens, U.S.N.M. no. E.7647).

Notes.—The specimens from off Cape Royds in 58 fathoms range in size from R = 35 mm to R = 6 mm. One of the smallest, with R = 6 mm, is 4-rayed. The largest has R = 35 mm, r = 13 mm.

The two specimens from the beach near Cape Royds measure R = 40 mm, r = 16 mm, and R = 33 mm, r = 18 mm.

The specimens from Marguerite Bay in 40 fathoms range from R = 32 mm to R = 12 mm.

Acodontaster elongatus (Sladen)

Gnathaster elongatus Sladen, *Challenger* Reports, Zoology, **30** (pt. 51): 288, pl. 48, figs. 1–4, pl. 49, figs. 5–10, pl. 19, figs. 5, 6. 1889.

Odontaster capitatus Koehler, Deuxième Expédition Antarctique Française (1908–1910), Échinodermes (Astéries, Ophiures et Échinides): 82, pl. 6, figs. 5, 8, 9, 11. 1912.

Localities.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (2 specimens, U.S.N.M. nos. E.7636, E.7694).

Island in Marguerite Bay; from tide pools along shore; February 21, 1948 (1 specimen, U.S.N.M. no. E.7637).

Notes.—In one of the specimens from Marguerite Bay in 35 fathoms (E.7636) R = 27 mm, r = 9 mm. The outer half of the rays is very slender. On the oral side in each interradius, about as far from the recurved tooth as the latter's length, there is a large 4-bladed pedicellaria surrounded by a bare space. In the other specimen R = 22 mm, r = 7 mm.

In the specimen from an island in Marguerite Bay R = 30 mm, r = 10 mm. There is only a single pedicellaria present which is not easily distinguishable from the surrounding spines.

All these specimens represent the form *capitatus* Koehler, originally described from a single specimen from Marguerite Bay.

GANERIIDAE

Perknaster aurantiacus Koehler

Perknaster aurantiacus Koehler, Deuxième Expédition Antarctique Française (1908–1910), Échinodermes (Astéries, Ophiures et Échinides): 36, pl. 3, fig. 9, pl. 4, fig. 1. 1912.

Locality.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (2 specimens, U.S.N.M. no. E.7695).

Note.—The two specimens measure R = 45 mm, r = 13 mm, and R = 20 mm, r = 6 mm.

SOLASTERIDAE

Cuenotaster involutus (Koehler)

Leucaster involutus Koehler, Deuxième Expédition Antarctique Française (1908–1910), Échinodermes (Astéries, Ophiures et Échinides): 55, pl. 5, figs. 1, 2, 3, 6, 7, 10, 11. 1912.

Locality.—Marguerite Bay; 40 fathoms; water temperature 30° F.; February 22, 1948 (1 specimen, U.S.N.M. no. E.7703).

Note.—The specimen measures R = 35 mm, r = 10 mm.

KORETHRASTERIDAE

Remaster gourdoni Koehler

Remaster gourdoni Koehler, Deuxième Expédition Antarctique Française (1908–1910), Échinodermes (Astéries, Ophiures et Échinides): 60, pl. 5, figs. 4, 5, 9, 12, pl. 8, fig. 7. 1912.

Locality.—Marguerite Bay; 35 fathoms; February 20, 1948 (3 specimens, U.S.N.M. no. E.7635).

Note.—In these specimens R varies from 7 to 9 mm.

ASTERIIDAE

Labidiaster annulatus Sladen

Labidiaster annulatus Sladen, *Challenger* Reports, Zoology, **30** (pt. 51): 595, pl. 108, fig. 1. 1889.

Locality.—Marguerite Bay; February 22, 1948 (1 specimen, U.S.N.M. no. E.7657).

Note.—This specimen has 36 arms 160 mm long; the disk is 50 mm in diameter.

Lysasterias perrieri (Studer)

Anasterias perrieri Studer, Jahrb. wiss. Anst. Hamburg **2**: 153. 1885.

Localities.—Off Knox coast, Antarctica (lat. 66° 31′ S., long. 111° 26′ E.); 100 fathoms; January 19, 1948 (1 specimen, U.S.N.M. no. E.7699).

Island in Marguerite Bay, from tide pools along the shore; February 21, 1948 (1 specimen, U.S.N.M. no. E.7700).

Marguerite Bay; 40 fathoms; water temperature 30° F.; February 22, 1948 (1 specimen, U.S.N.M. no. E.7701).

Notes.—In the specimen from the island in Marguerite Bay R = 50 mm, r = 10 mm. In the specimen from Marguerite Bay in 40 fathoms R = 30 mm, r = 5 mm.

Lysasterias joffrei (Koehler)

Paedasterias joffrei Koehler, Australasian Antarctic Expedition 1911–14, Scientific Reports, Series C, Zoology and Botany **8** (pt. 1), Echinodermata Asteroidea: 30, pl. 1, figs. 3, 4, 9, pl. 2, figs. 7, 8, 9, pl. 56, fig. 2. 1920.

Locality.—Island in Marguerite Bay, from tide pools along the shore: February 21, 1948 (1 specimen, U.S.N.M. no. E.7702).

Note.—In this specimen R = 90 mm, r = 15 mm.

Adelasterias papillosa (Koehler)

Diploasterias papillosa Koehler, Expédition Antarctique Française (1903–1905): 21, pl. 1, figs. 2–5, pl. 2, figs. 18, 19. 1906.

Localities.—Marguerite Bay; 35 fathoms; water temperature 30° F.; February 20, 1948 (1 specimen, U.S.N.M. no. E.7696).

Island in Marguerite Bay, from tide pools along the shore; February 21, 1948 (1 specimen, U.S.N.M. no. E.7697).

Note.—The specimens measure R = 15–16 mm, r = 4 mm.

MALACOLOGY.—*Recent species of the prionodont pelecypod* Cucullaea[1]. DAVID NICOL, U. S. National Museum.

A review of the living species of *Cucullaea* has not been made since Lamy (1907, pp. 306, 307) made one more than 40 years ago, although Iredale (1939, pp. 250–252) thoroughly reviewed the species names.

This study is the second of a series on relict marine bivalve families, and its scope is the same as that made on the fimbriids. The cucullaeids, like the fimbriids, have a history dating back to the early Jurassic. During Jurassic and Cretaceous times the cucullaeids were abundant in number of species and world-wide in distribution. Rapid decline became apparent after the early Eocene, and the family has since been much restricted in its distribution and number of species. Today the group is found in the Indian Ocean and the western part of the Pacific Ocean. From this brief history of the cucullaeids, it is interesting to note the amazing parallelism with the fimbriids. In minor details there are differences, and the two groups do not quite occupy the same ranges today; but the over-all picture is much alike for both families. Ecologic factors do not enter into this parallelism if we consider the evidence on the basis of the living species.

Genus **Cucullaea** Lamarck, 1801

Genotype.—Cucullaea auriculifera Lamarck, 1801 = *Arca cucullata* Röding, 1798 = *Arca cucullus* Gmelin, 1791 = *Arca labiata* Solander, 1786. Subsequent designation, J. G. Children, 1823, p. 318.

Winckworth (1944, p. 231) listed two earlier genotype designations for *Cucullaea*, but neither of these is valid. Schmidt (1818, p. 65) designated *Arca cucullus* Gmelin as the genotype, but this species name was not included in Lamarck's original description, nor can *Arca cucullus* Gmelin be considered as an objective synonym of *Arca cucullata* of Chemnitz. Fleming (1818, p. 306) made the following statement concerning *Cucullaea*: "In the genus *Cucullaea*, the teeth of the hinge are similar to the Arcae, but at each extremity there are three or four transverse parallel ribs. It is represented by the *Arca cucullata* of Chemnitz. Conch. VII, p. 174. tab. 55, f. 526–528." This cannot be construed as a genotype designation, and, furthermore, it is certainly not clear that Fleming was referring to types in the modern sense.

Cucullaea labiata (Solander)

Figs. 1–8

1786. *Arca labiata* Solander, Catalogue Portland Museum: 185, lot 3947.
1789. *Arca concamera* Bruguière, Encyclopédie méthodique, histoire naturelle des vers, texte 1 (aber-con): 102, 103.
1791. *Arca cucullus* Gmelin, Systema naturae, ed. 13, **1**(6): 3311.
1798. *Arca cucullata* Röding, Museum Boltenianum, pt. **2**: 173, no. 207.
1801. *Cucullaea auriculifera* Lamarck, Système des animaux sans vertèbres: 116.
1835. *Arca concamerata* Deshayes, Histoire naturelle des animaux sans vertèbres, ed. 2, **6**: 454.
1846. *Cucullaea granulosa* Jonas, Proc. Zool. Soc. London, 1846, pt. **14**: 34, 35.
1857. *Cucullaea concamerata* (Deshayes), Deshayes, Traité élémentaire de conchyliologie **2**: 379, 380, pl. 36, figs. 12, 13.
1860. *Cucullaea plicata* Theobald [nomen nudum], Catalogue Recent shells Museum Asiatic Society of Bengal: 126.
1869. *Cucullaea concamerata* (Deshayes), Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 1, fig. 1.
1869. *Cucullaea granulosa* Jonas, Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 2, figs. 2a, b.
1869. *Cucullaea auriculifera* Lamarck, Reeve, Conchologia iconica **17**: Genus *Cucullaea*, species 3, fig. 3.
1891. *Cucullaea concamerata* (Deshayes), Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz, Die Gattung *Arca L.*, **8**(2): 5, 6, pl. 1, figs. 3, 4, pl. 5, figs. 1, 2.
1891. *Cucullaea granulosa* Jonas, Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz, Die Gattung *Arca* L., **8** (2): 6, 228, pl. 1, fig. 5.
1907. *Cucullaea concamerata* (Deshayes), Lamy, Journ. Conchyl. **55**(3): 306.
1907. *Cucullaea granulosa* Jonas, Lamy, Journ. Conchyl. **55**(3): 306, 307.
1909. *Arca* (*Cucullaea*) *concamerata* Deshayes, Lynge, Danish expedition to Siam 1899–1900, IV: Marine Lamellibranchiata: 128.
1930. *Cucullaea vaga* Iredale, Rec. Australian Mus. **17**(9): 385.
1939. *Cucullaea labiata petita* Iredale, Great Barrier Reef expedition 1928–29, Scientific Reports, **5**(6): Mollusca pt. 1: 250–252, pl. 2, figs. 1a, 17, 17a, 17b.

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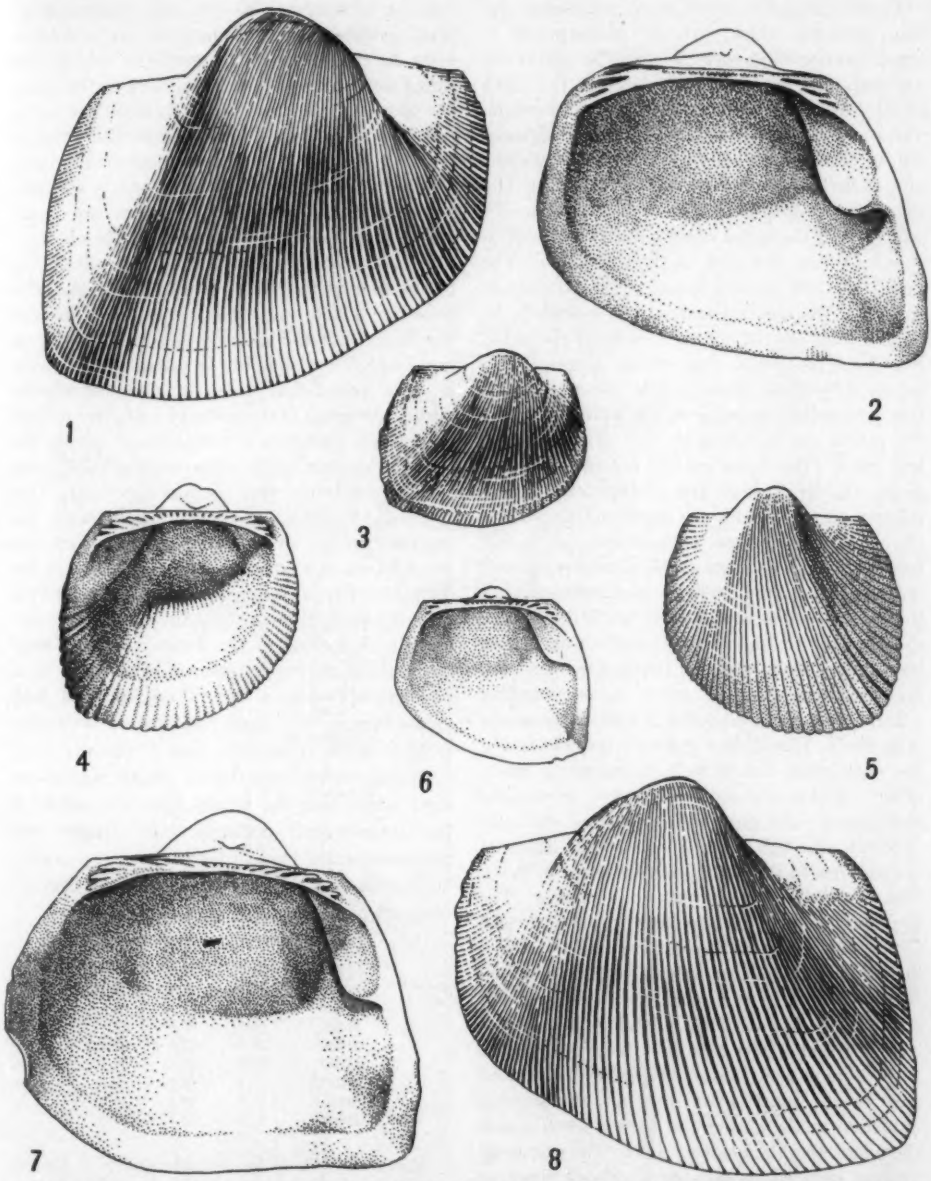

FIGS. 1–8.—*Cucullaea labiata* (Solander) (all specimens are in the U. S. National Museum Collection): 1, Exterior of right valve, × ⅝, Torres Straits, U.S.N.M. no. 149920; 2, interior of right valve, × ⅝, India, U.S.N.M. no. 149921; 3, exterior of right valve, × ⅝, Manila Bay, Luzón, U.S.N.M. no. 255093; 4, interior of left valve, × 3½, Balukbaluk Island, Sulu Archipelago, U.S.N.M. no. 293754 (note groove on umbonal margin and arrangement of teeth in this small specimen); 5, same valve as Fig. 4, exterior, × 3½; 6, interior of right valve, × ⅝, near Cebu, U.S.N.M. no. 236880; 7, interior of right valve, × ⅝, near Pratas Island, U.S.N.M. no. 255098; 8, same specimen as Fig. 1, exterior, left valve, × ⅝.

Description.—The shell is porcellaneous and thin, and the thick, velvety periostracum is better developed in cooler water. The valves are unequal, the left valve overlapping the right along the posteroventral and ventral borders. Valve outline can be subquadrate, subtrapezoidal, or subtrigonal, whereas the posterior side is always flattened and more or less truncated. The valves are subequilateral and do not gape. In young shells the radial ribs are raised and tend to split, and new ribs form in the interspaces. The radial ribs are usually broader than the interspaces. There are concentric raised threads at regular intervals. In mature specimens the radial ribs tend to flatten and widen; less splitting occurs. Concentric threads give the ornamentation a cancellate appearance. On some specimens the radial ribs are broader and flatter on the left valve. The variation in ornamentation is great. On large shells the crenulations on the interior ventral border are small and numerous. On small shells these crenulations are better marked and are also seen on the anteroventral and posteroventral margins. In the smallest specimens these crenulations are strongly marked, and the ribs are reflected on the interior of the shell. The beaks are orthogyrate. In young specimens the umbonal area shows a groove located slightly anterior to the center, but it is difficult to see on large shells. This shallow groove is not confined to the cucullaeids but is well developed in many other prionodonts and may have systematic importance. The ligament is external and amphidetic, although slightly more of the ligament lies anterior to the beaks than posterior to them. The ligamental area is flat and shallow. The ligament shows only fine lines running parallel to its long axis, and the loss of well-developed ligamental chevrons is a late development among the cucullaeids. In small shells the teeth are nearly all the same size and look much like the teeth of *Anadara* and *Glycymeris*. The larger specimens show a reduction in the height of the central part of the hinge plate, and a corresponding reduction in the size of the central teeth makes them look like the blade of a saw. The side teeth become reduced in number to about three or four on each end, become elongate, and are arranged nearly parallel to the ligament. The reduction in the height of the hinge plate is another late development in the cucullaeids. The number of teeth is variable, but on small shells there are about 17, whereas on large ones there may be as many as 30. On some intermediate-sized specimens a few of the teeth are hooked or even chevron-shaped. The posterior side of the hinge plate extends ventrally a little farther than the anterior side, and often there is one more posterior side tooth. On large shells the anterior part of the posterior adductor muscle lies on a built-out flange of shell material; this is not seen in small shells. The posterior side of the cucullaeid is so truncated that in order for the adductor muscle to exert a force to close the valves, the flange appears to be a mechanical necessity. The anterior adductor muscle scar has only a trace of the flange, but the anterior side is not nearly so truncated. The pallial line is integripalliate, with a slight indentation where it joins the ventral part of the flange of the posterior adductor muscle scar. Color variation is considerable among the cucullaeids. Specimens from southern Japanese waters are often deep purple interiorly. One specimen from India is light purple along the posterior margin of the interior of the shell and has a brown and purple streak at the base of the flange for the posterior adductor muscle. Shells from the Philippines are light brown to orange exteriorly. According to Dr. Joyce Allan (personal communication), specimens of *Cucullaea* from northern Queensland waters are splashed with yellow-orange, and those from the cooler waters of New South Wales have darker colors.

Measurements.—Maximum length was measured rather than the length from the middle of the anterior and posterior ends. Height was measured on the basis of the left, or larger, valve. Only specimens with both valves were measured. Measurements, in millimeters, are as follows:

U. S. N. M. no.	*Length*	*Height*	*Convexity (both valves)*
346134A	99.6	78.4	73.4
149920	90.4	72.4	65.8
273673	81.6	67.0	57.9
249497	78.8	65.5	58.2
149921	77.5	63.0	53.7
273673A	77.4	62.9	52.5
346134	71.5	61.4	53.3
236880	38.5	33.3	26.0

Remarks.—There are 110 specimens of Recent cucullaeids in the U. S. National Museum collection. Most of them are small shells dredged by the *Albatross*.

Locality data.—Specimens from the following localities are in the U. S. National Museum collection:

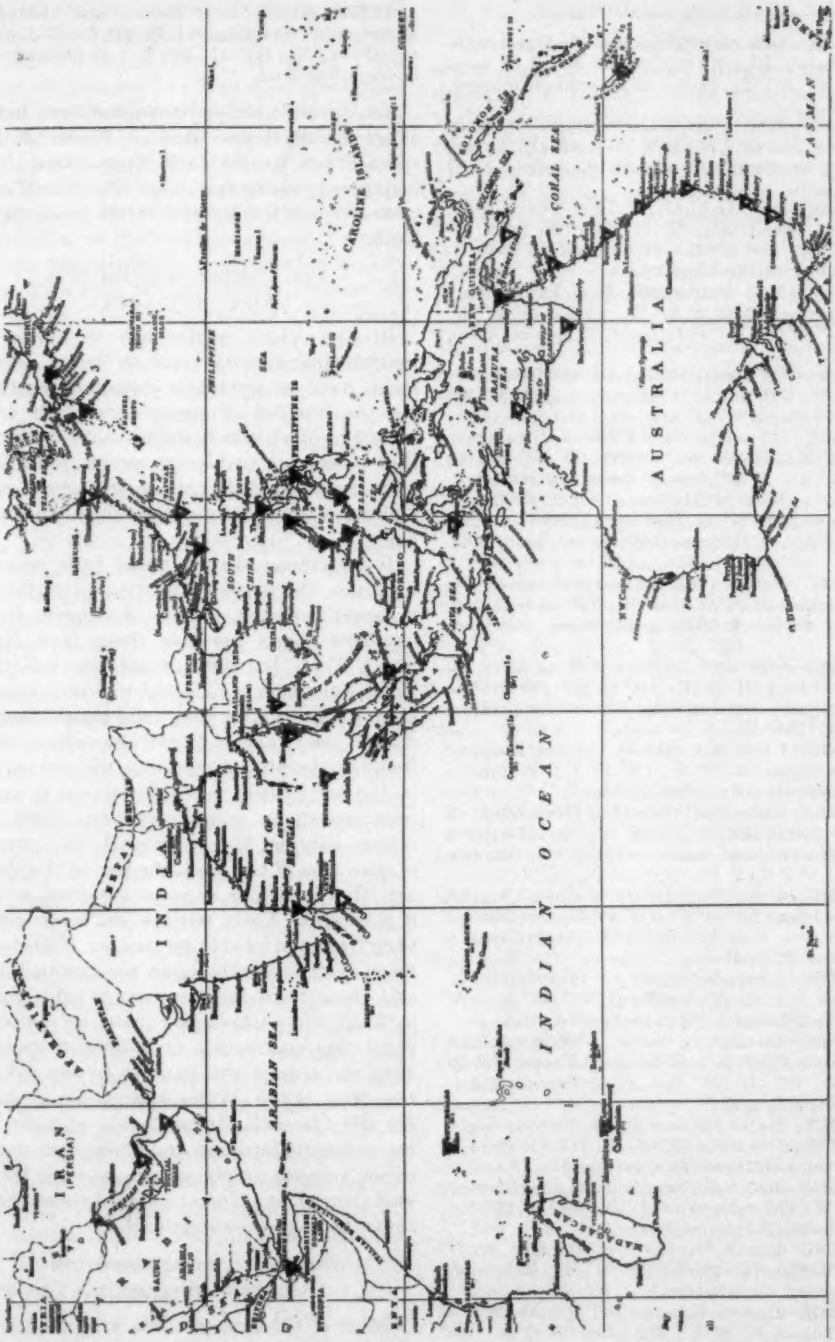

FIG. 9.—Distribution of living specimens of *Cucullaea labiata* (Solander): ▼, Locality data based on U. S. National Museum specimens; ▽, locality data based on specimens in other museums and on published records.

ALBATROSS DREDGING STATIONS

D.5134—Sulu Archipelago near Basilan Island, Balukbaluk Island (N.), S. 59° W., 6.25 miles (6° 44′ 45″ N., 121° 48′ E.). 25 fathoms (45 meters), fine sand.

D.5146—Sulu Archipelago, vicinity of Siasi, Sulade Island (E.), N. 18° W., 3.40 miles (5° 46′ 40″ N., 120° 48′ 50″ E.). 24 fathoms (43 meters), coral sand, shells.

D.5161—Sulu Archipelago, Tawi Tawi Group, Tinakta Island (E.), N. 12° W., 1.80 miles (5° 10′ 15″ N., 119° 53′ E.). 16 fathoms (29 meters), fine sand with black specks.

D.5164—Sulu Archipelago, Tawi Tawi Group, Observation Island, S. 82° W., 8 miles (5° 01′ 40″ N., 119° 52′ 20″ E.). 18 fathoms (33 meters), green mud.

D.5181—Off eastern Panay, Antonia Island (S.), S. 63° W., 6.60 miles (11° 36′ 40″ N., 123° 26′ 35″ E.). 26 fathoms (47 meters), mud and fine sand.

D.5192—Off northern Cebu Island, Jilantaguan Island (E.), N. 13° W., 3 miles (11° 09′ 15″ N., 123° 50′ E.). 32 fathoms (58 meters), green sand.

D.5213—East of Masbate Island, Destacado Island (S.), N. 87° E., 8.50 miles (12° 15′ N., 123° 57′ 30″ E.). 80 fathoms (146 meters), sand, mud, shells.

D.5220—Between Marinduque and Luzon, San Andreas Island (W.), S. 57° W., 8.50 miles (13° 38′ N., 121° 58′ E.). 50 fathoms (91 meters), soft green mud.

D.5310—China Sea, vicinity of Hong Kong, off Pratas Island (21° 33′ N., 116° 13′ E.). 100 fathoms (183 meters), sand, shells, bottom temperature 65.5° F (18.6° C).

D.5311—China Sea, vicinity of Hong Kong, off Pratas Island (21° 33′ N., 116° 15′ E.). 88 fathoms (158 meters), coarse sand, shells.

D.5312—China Sea, vicinity of Hong Kong, off Pratas Island (21° 30′ N., 116° 32′ E.). 140 fathoms (252 meters), sand, small shells, bottom temperature 57.5° F (14.2° C).

D.5314—China Sea, vicinity of Hong Kong, off Pratas Island (21° 41′ N., 116° 46′ E.). 122 fathoms (220 meters), sand, broken shells, bottom temperature 59.5° F (15.3° C).

D.5336—Linapacan Strait off Observatory Island (N.), S. 42° W., 9 miles (11° 37′ 45″ N., 119° 46′ E.). 46 fathoms (83 meters), sand, mud.

D.5342—Malampaya Sound, Palawan Island, Endeavor Point (S.), S. 58° E., 0.5 miles (10° 56′ 55″ N., 119° 17′ 24″ E.). 14–25 fathoms (25–45 meters), gray mud.

D.5357—North Balabac Strait, Balabac Light, S. 65° W., 14.3 miles (8° 06′ N., 117° 17′ 10″ E.). 68 fathoms (122 meters), coral, sand.

D.5358—Jolo Sea, Sandakan Light (Borneo), S. 34° W., 19.7 miles (6° 06′ 40″ N., 118° 18′ 15″ E.). 39 fathoms (70 meters), mud.

D.5360—Manila Bay, Corregidor Light, N. 74° W., 6.9 miles (14° 21′ N., 120° 41′ E.). 12 fathoms (22 meters), hard bottom.

D.5426—Eastern Palawan and vicinity, 30th of June Island, N. 29° E., 12.2 miles (9° 12′ N., 118° 28′ E.). 27 fathoms (49 meters), fine gray sand.

D.5593—Sibuko Bay, Borneo and vicinity, Mount Putri (sea tangent), N. 52° W., 17.2 miles (4° 02′ 40″ N., 118° 11′ 20″ E.). 38 fathoms (68 meters), fine sand.

Additional localities represented are: India, Japan (Awaji, Boshu? [Boshiu?, Boshin?],Kagoshima Strait, Kyushu), and Torres Straits. The map accompanying this paper (Fig. 9) will give more complete locality data on the living cucullaeids.

THE SPECIES PROBLEM IN LIVING CUCULLAEA

In the past, inadequate descriptions, figures, and locality data on living cucullaeids have caused much confusion concerning the number of species and their true identity. Most conchologists have believed that there were two living species, but a few have maintained that there were three, and still fewer have claimed that there was only one.

If specimens are examined from several localities, the bewildering array of variation becomes apparent at once. Specimens from southern Japan resemble those from New South Wales, but they are not identical with them. Cucullaeids collected in cooler waters seem to have flatter ribs, more periostracum, darker color, and a more subquadrate outline. Ornamentation varies on the two valves of the same shell, and this feature is more pronounced on some specimens than on others. Ribbing also varies with the amount of corrosion of the shell, the size of the shell, and the particular area on the shell where it is studied. Valve outline and hinge teeth vary from one locality to another. The specimens from southern Japan are subquadrate, and those from India are more subtrigonal in form. If conchologists insist on splitting the living cucullaeids into distinct species, then one species will have to be erected for the New South Wales specimens, another for the Queensland specimens, another for the southern Japanese and China Seas specimens, another for the specimens from India, and so on. I am prone to regard these variations, at most, as subspecies.

ECOLOGY AND DISTRIBUTION OF CUCULLAEA

Most of the ecologic data are taken from the records on the *Albatross* dredging sta-

tions. There are, however, a few additional observations scattered through the literature on Indo-Pacific mollusks. As far as I am aware, all data are based on dead specimens. Living cucullaeids prefer fine sand or mud bottoms, and they have not been reported at depths greater than 252 meters. They have been found most commonly at depths ranging from 15 to 150 meters but have been collected in as little as five meters of water. Bottom temperatures were recorded in only three Albatross stations where cucullaeids were found. These temperatures ranged from 14.2° C to 18.6° C; and probably the other stations would, for the most part, have a bottom temperature nearer the higher figure, for they were all at shallower depths than the one from which the lowest temperature was recorded. *Cucullaea* does not appear to be associated with coral reefs and seems to be able to withstand lower temperatures than reef corals. The fact that cucullaeids are not associated with reef corals may explain the gaps in their distribution.

Cucullaea labiata is a variable and wide-ranging species. It has been reported living as far west as the Gulf of Aden and near Djibouti on the African east coast, but it has not been reported further south along the African coast. In the Red Sea it has been reported only as "subfossil." *Cucullaea labiata* occurs in Mauritius but has not been reported from Madagascar, although the molluscan fauna of the latter island has been studied with some degree of completeness. The family ranges eastward and is found in the Persian Gulf, Gulf of Oman, India, Malaya, Siam, the Philippine Islands, and thence north and south to Japan and Australia, respectively. In Australia the known distribution of *Cucullaea* is from Melville Island in Northern Territory eastward and southward along the Queensland coast and into New South Wales as far south as Shoalhaven below Sydney. Chavan (1907, p. 307) reports *Cucullaea* from New Caledonia, but no one else has mentioned it from this region. Continued collecting may show that *Cucullaea* occurs farther west in Australia and also farther south along the east coast of Africa and perhaps in Madagascar.

ACKNOWLEDGMENTS

Dr. Joyce Allan, of the Australian Museum, gave me detailed descriptions and drawings of the Australian cucullaeids as well as data on their geographical distribution. Dr. L. R. Cox, of the British Museum (Natural History), looked for the type specimens of *Cucullaea granulosa* Jonas. The following persons gave geographical data from the specimens of cucullaeids in their collections: Wm. J. Clench, Museum of Comparative Zoology; Dr. Leo G. Hertlein, California Academy of Sciences; and Dr. A. Myra Keen, Stanford University. This study could not have been completed without the help of these persons.

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MAMMALOGY.—*An undescribed pika from Utah.*[1]

MARSHALL C. GARDNER, U S. Fish and Wildlife Service. (Communicated by Hartley H. T. Jackson.)

Albert W. Moore, of the Portland, Oreg., office of the branch of wildlife research of the U. S. Fish and Wildlife Service, recently suggested that certain pikas collected by him in 1928 in Utah might represent a new race. Upon examination they were found to be considerably different from *Ochotona princeps nevadensis*, the identification previously assigned to them. This new race is named in honor of Mr. Moore. Measurements are in millimeters.

Ochotona princeps moorei, n. subsp.

Type specimen.—Adult ♀, skin and skull, U.S.N.M. no. 248436, (Biological Surveys collection); collected July 18, 1928, 1 mile northeast of Baldy Ranger Station, Manti National Forest, altitude 10,000 feet, Sanpete County, Utah, by A. W. Moore; original number, 470. The station is 17 miles east and 2 miles south of Gunnison, Utah.

Geographic range.—Known only from the type locality.

Diagnostic characters.—Compared with *Ochotona princeps nevadensis*, the new subspecies is generally smaller in size and is less buffy on the sides. The nasals of *moorei* are shorter and are more rounded and less truncate posteriorly. The lateral margins are more concave and the palatal bridge is narrower. The subspecies *moorei* resembles *O. p. uinta* but is smaller and has less buffy upper parts and blacker ears. The skull is also slightly smaller with shorter nasals and with the anterior margin of the palatal bridge concave and not straight. From *O. p. saxatilis* it also differs in being generally smaller and having darker ears. The nasals are considerably shorter and the ventral surface of the basioccipital is not ridged as in *saxatilis*. The auditory bullae are more rounded. When compared to *O. p. utahensis* the body and skull are smaller, the hind foot longer, and the upper parts more buffy. The nasal length and palatal bridge width are less. In comparison to *O. p. clamosa* the new race is smaller and has the upper parts less blackish and more buffy. In the skull the lateral nasal margins are concave rather than straight, the interpterygoid space parallel-sided rather than spatulate and the auditory bullae less inflated. When compared to *O. p. cinnamomea* the head and neck are more buffy and the total length is less. The hind foot and skull are larger, however. The nasals are longer and more expanded anteriorly. *O. p. moorei* is more buffy on the head and neck than *O. p. fuscipes* with the throat less cinnamon and both the upper parts and under parts paler. The lateral nasal margins are more concave and the palatal bridge is broader. Finally, in comparison with specimens of *O. p. tutelata* from the Toyabe Mountains the new race has less cinnamon both dorsally and ventrally and has a longer hind foot. The skull is larger with longer nasals and with the lateral margins more concave.

Color.—(Capitalized terms according to Ridgway: *Color standards* and *color nomenclature*. 1912.) Type (worn winter pelage except for the head and shoulder which are acquiring the summer pelage): Upper parts near Light Ochraceous Buff. Under parts whitish washed with near Pinkish Buff.

Skull.—Medium in size; nasals short with lateral margins concave; anterior margin of palatal bridge concave; interpterygoid space parallel-sided.

Measurements.—Type (adult ♀): Total length, 177; foot length, 31; occipitonasal length, 43.0; zygomatic breadth, 21.3; cranial breadth, 18.5; interorbital breadth, 5.1; palatal bridge width, 2.0; nasal length, 13.8.

Specimens examined.—Three, from the type locality.

[1] Received June 21, 1950.